EXHIBIT A

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Boyd et al.

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(45) **Date of Patent:** **Sep. 3, 2019**

(54) **APPLIANCE IMMERSION COOLING SYSTEM**

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§ 371 (c)(1),
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Related U.S. Application Data

(60) Provisional application No. 61/737,200, filed on Dec. 14, 2012, provisional application No. 61/832,211, filed on Jun. 7, 2013.

(51) **Int. Cl.**
H01L 23/44 (2006.01)
H05K 7/20 (2006.01)

(52) **U.S. Cl.**
CPC ***H05K 7/20236*** (2013.01); ***H01L 23/44*** (2013.01); ***H05K 7/20272*** (2013.01)

(58) **Field of Classification Search**
CPC H05K 7/20236; H05K 7/20272; H01L 23/42; H01L 23/44
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,590,538 A *	5/1986	Cray, Jr.	....	H05K 7/20236 361/700
5,167,511 A *	12/1992	Krajewski	....	H01R 4/01 361/785

(Continued)

FOREIGN PATENT DOCUMENTS

JP	5956100 B1 *	7/2016	.... G06F 1/20
RU	2042294 C1	8/1995	
SU	1764094 A1	9/1992	

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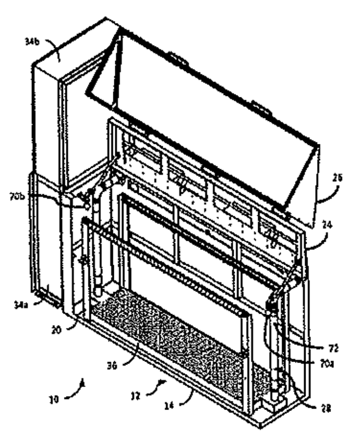
(74) *Attorney, Agent, or Firm* — Jeffrey Van Myers

(57) **ABSTRACT**

A appliance immersion tank system comprising: a generally rectangular tank adapted to immerse in a dielectric fluid a plurality of appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, the long axis of the tank; a primary circulation facility adapted to circulate the dielectric fluid through the tank; a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted; and a control facility adapted to coordinate the operation of the primary and secondary fluid circulation facilities as a function of the temperature of the dielectric fluid in the tank. A plenum, positioned adjacent the bottom of the tank, is adapted to dispense the dielectric fluid substantially uni-
(Continued)



formly upwardly through each appliance slot. A weir, integrated horizontally into a long wall of the tank, is adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot. All active and most passive components of both the primary and secondary fluid circulation facilities, and the control facility are fully redundant, and are adapted automatically to operate in a fail-soft mode.

16 Claims, 7 Drawing Sheets

(58) **Field of Classification Search**
USPC 361/699
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,297,621	A *	3/1994	Taraci	G01R 31/2891 165/104.13
8,009,419	B2	8/2011	Attlesey et al.	
2005/0259402	A1*	11/2005	Yasui	H02M 7/003 361/716
2006/0126292	A1*	6/2006	Pfahnl	H05K 7/20563 361/695
2006/0274501	A1*	12/2006	Miller	G01R 31/2863 361/690
2011/0075353	A1*	3/2011	Attlesey	G06F 1/20 361/679.47
2011/0132579	A1*	6/2011	Best	H05K 7/20763 165/104.31
2011/0240281	A1*	10/2011	Avery	G05D 23/1917 165/287

* cited by examiner

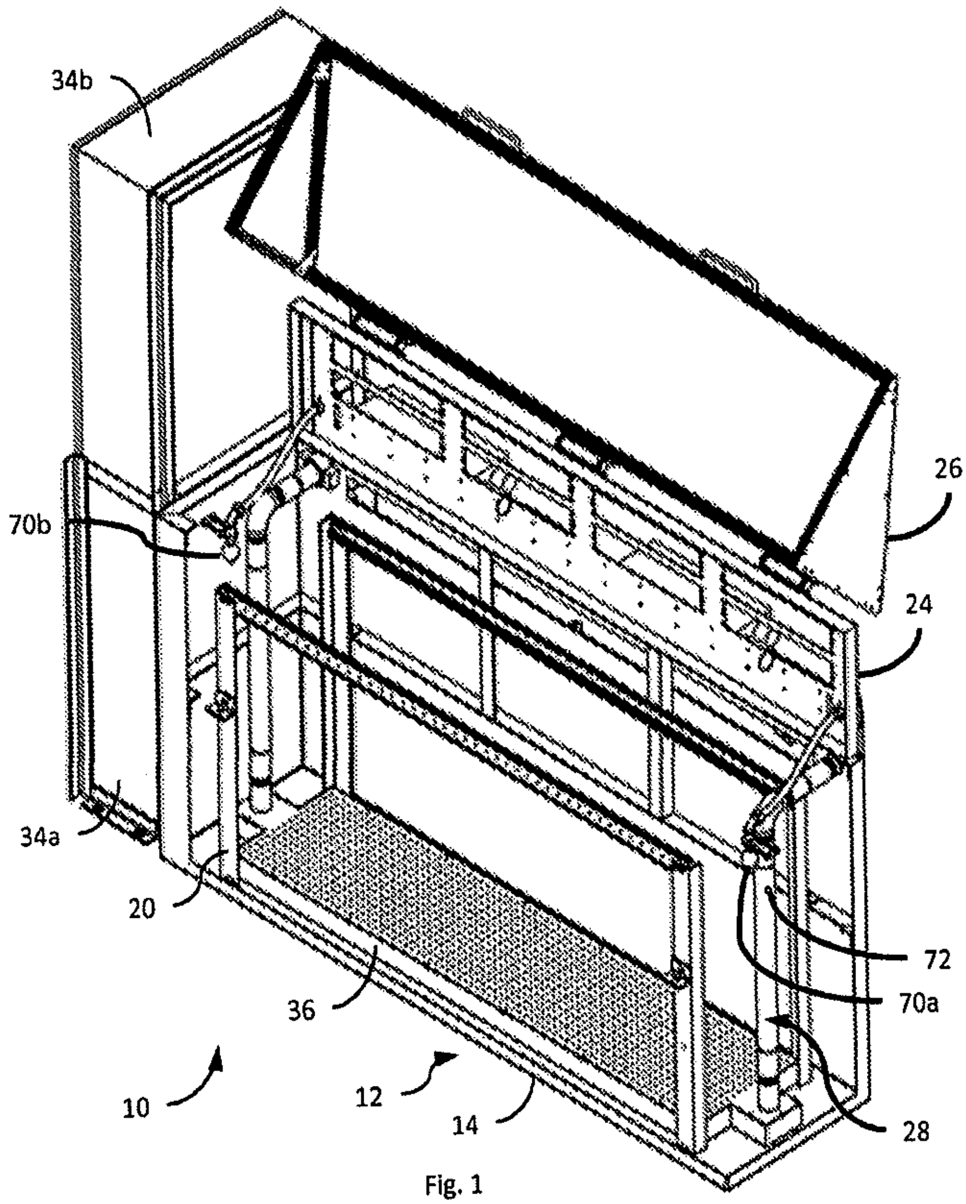


Fig. 1

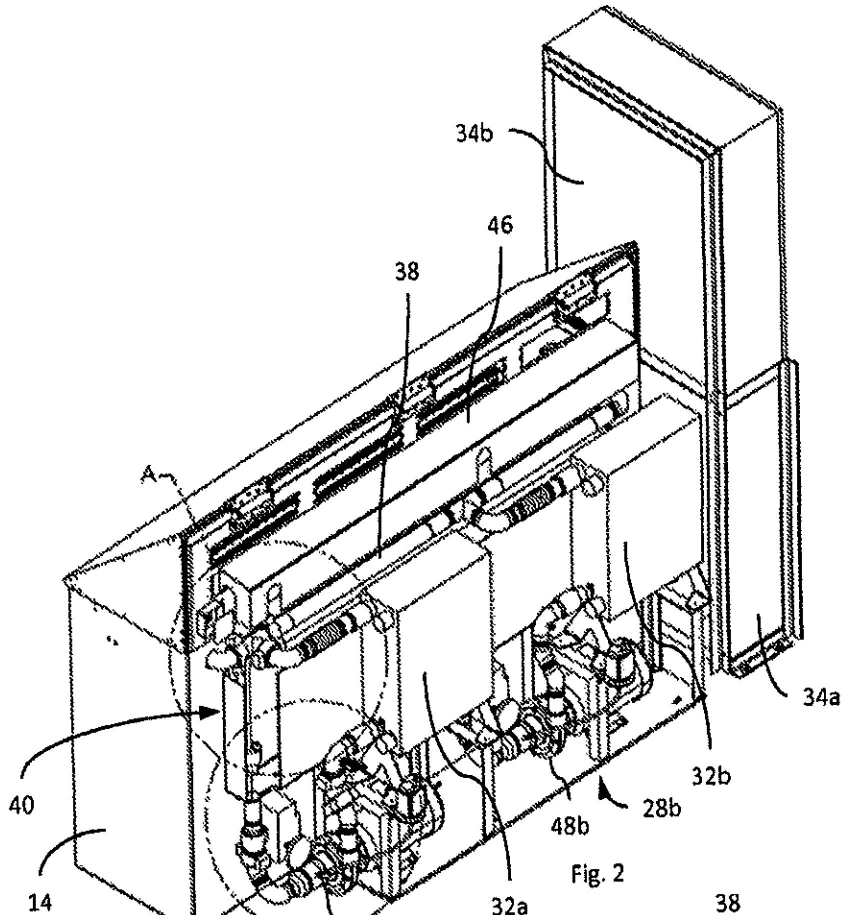


Fig. 2

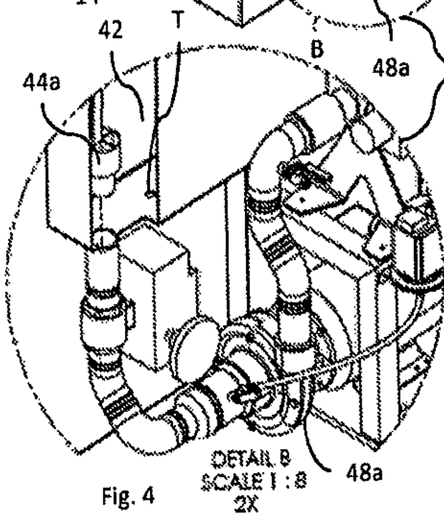


Fig. 4

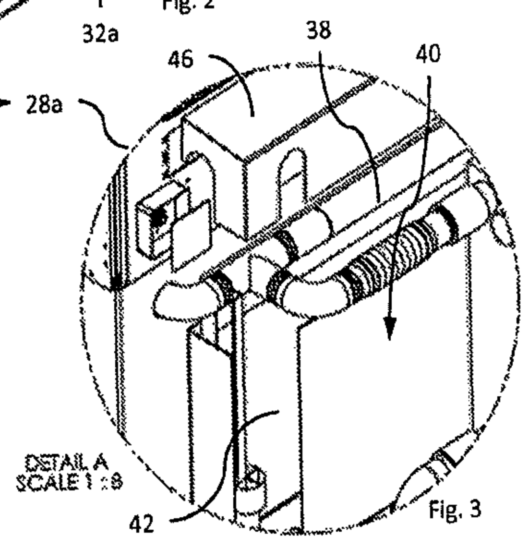


Fig. 3

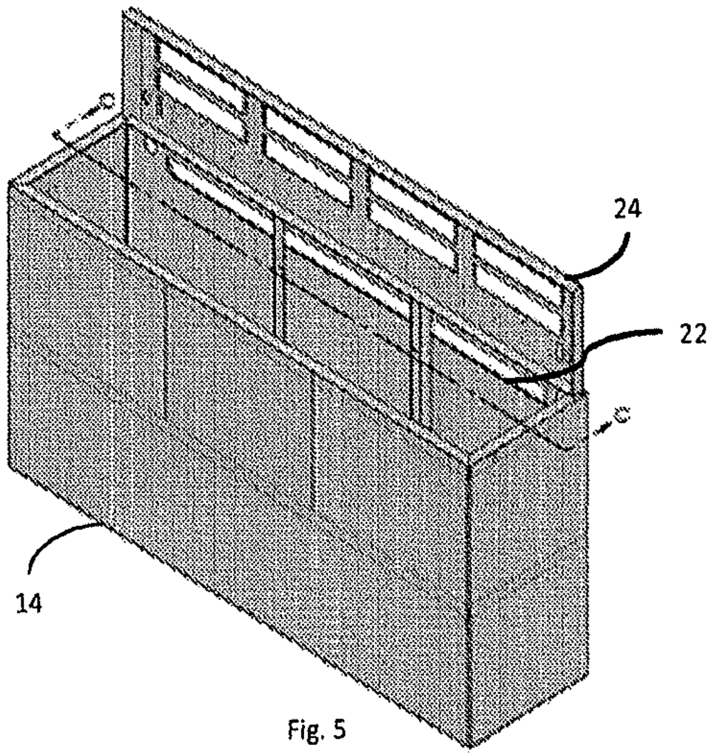
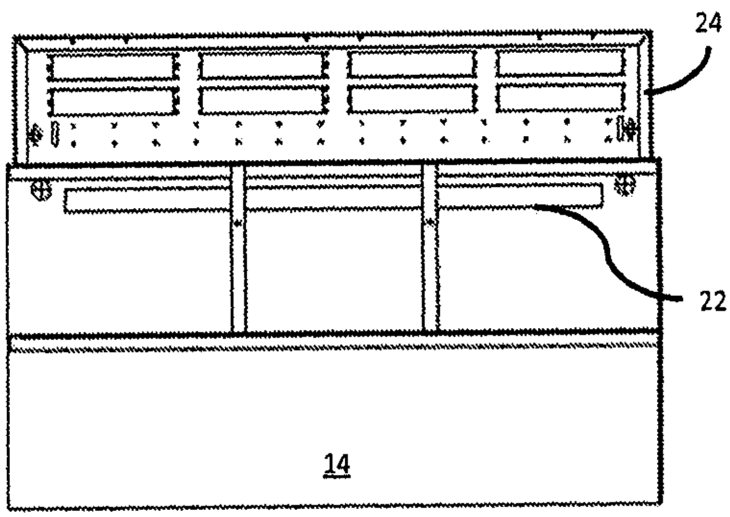


Fig. 5



Section C-C
Fig. 6

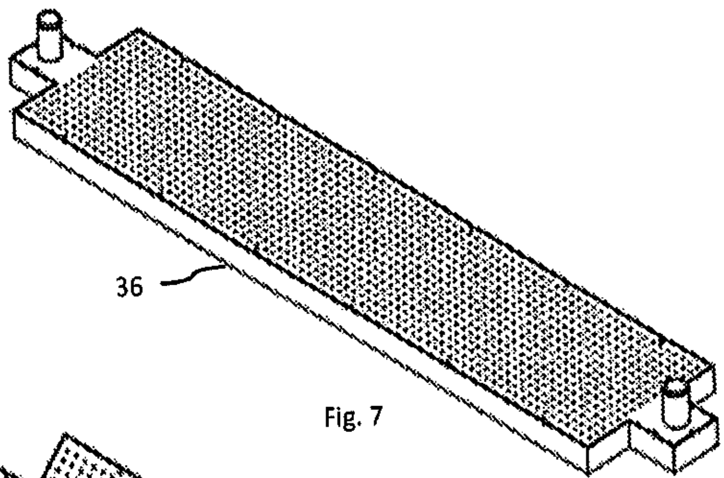


Fig. 7

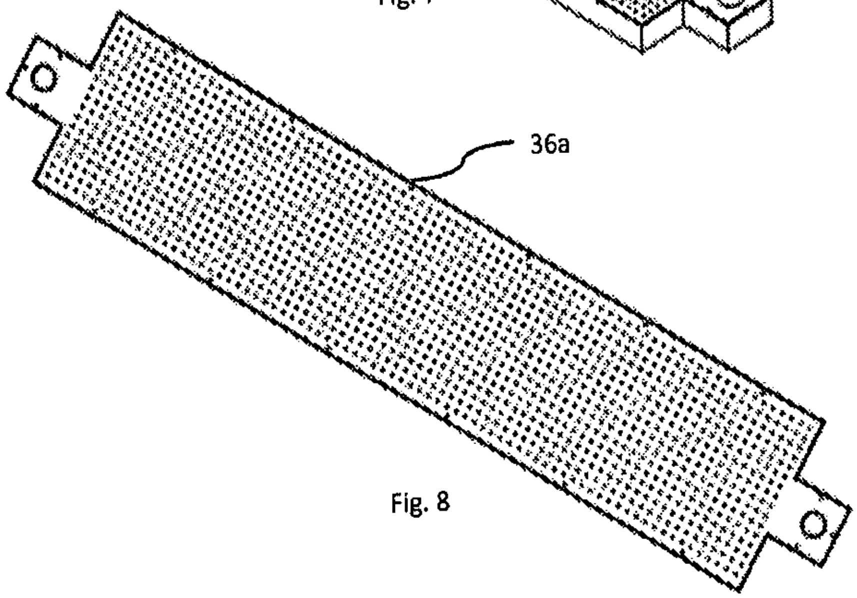


Fig. 8

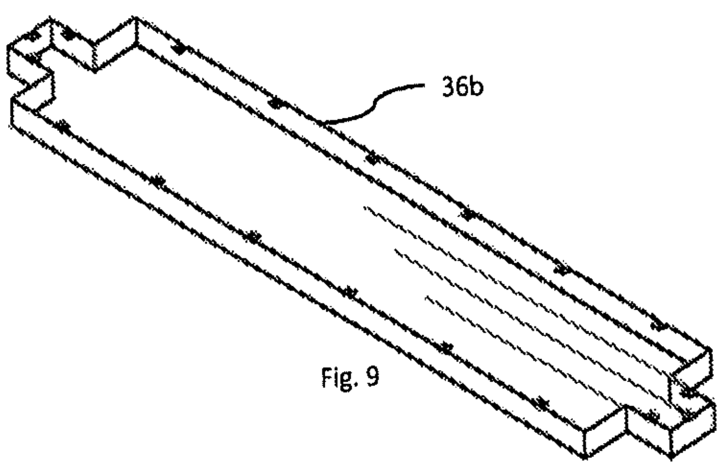


Fig. 9

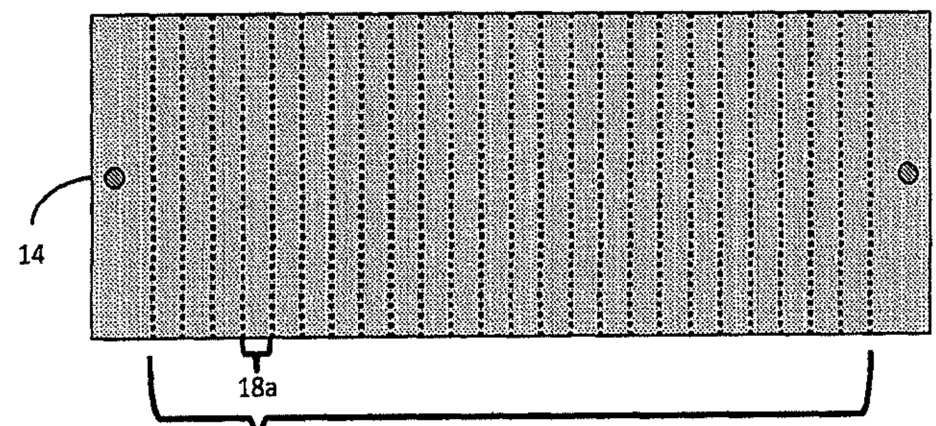


Fig. 10

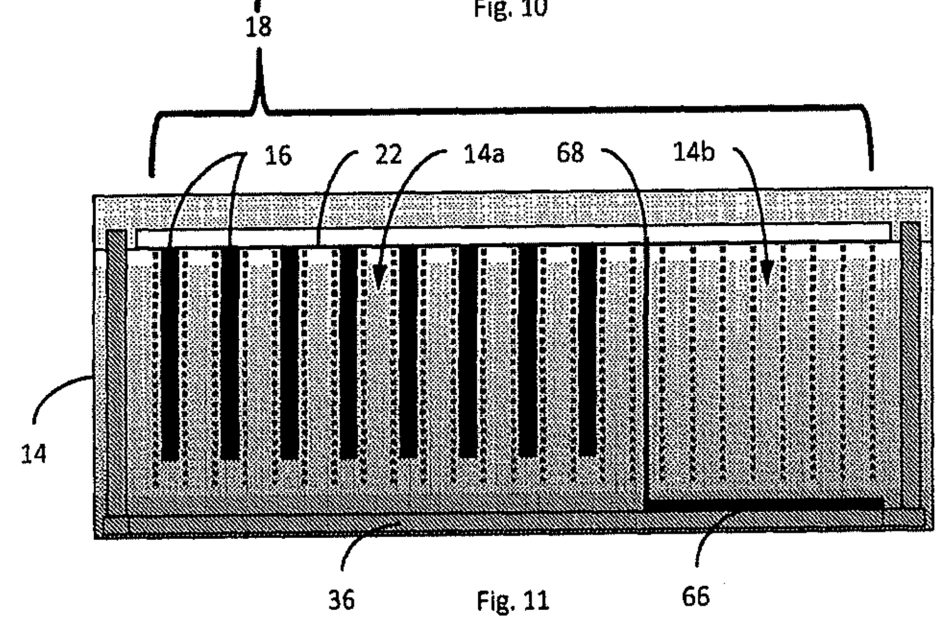
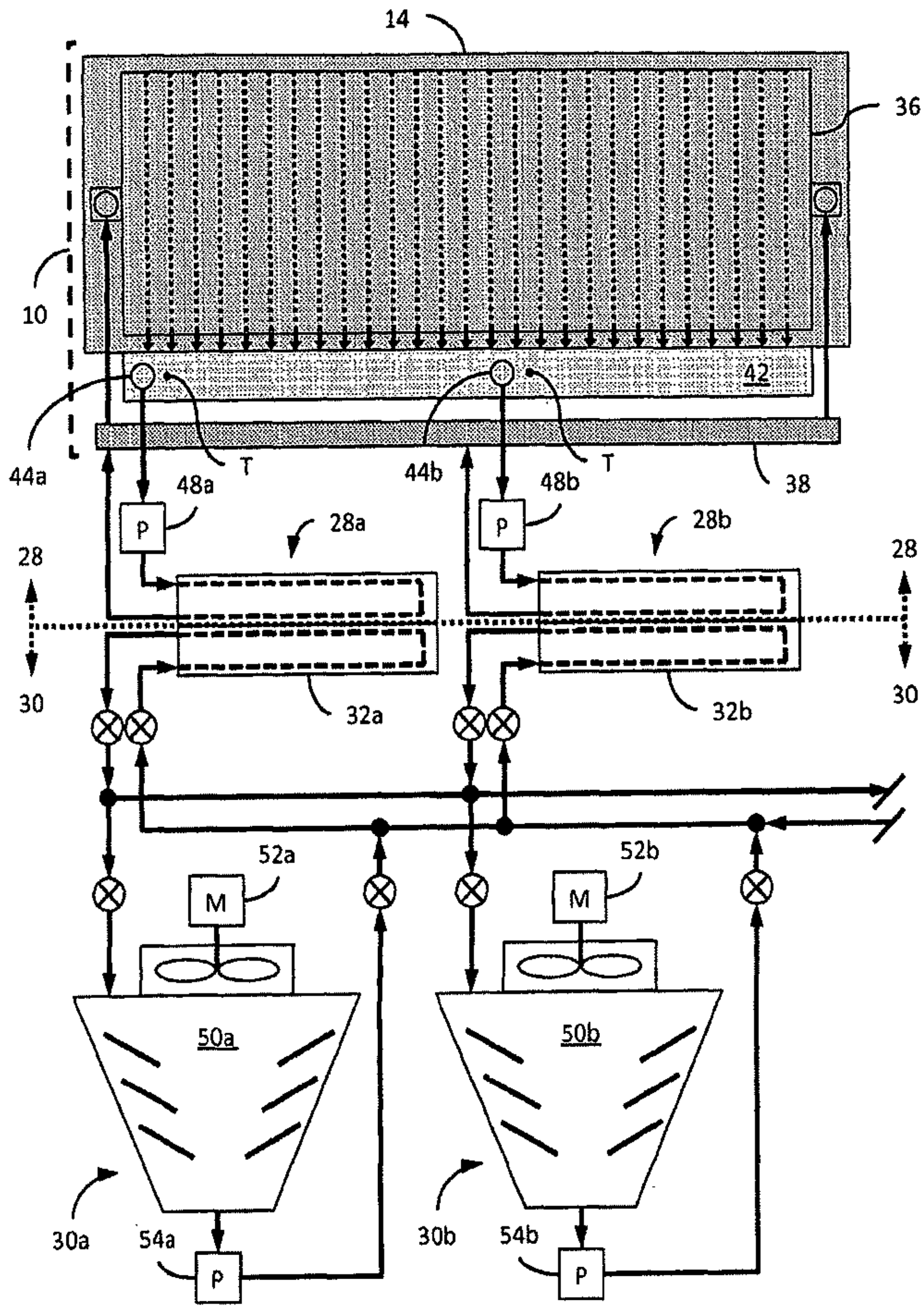


Fig. 11



14
36
10
42
44a
T
48a
44b
48b
T
38
P
P
28a
28b
28
28
30
30
32a
32b
52a
52b
M
M
50a
50b
30a
54a
30b
54b
P
P

Fig. 12

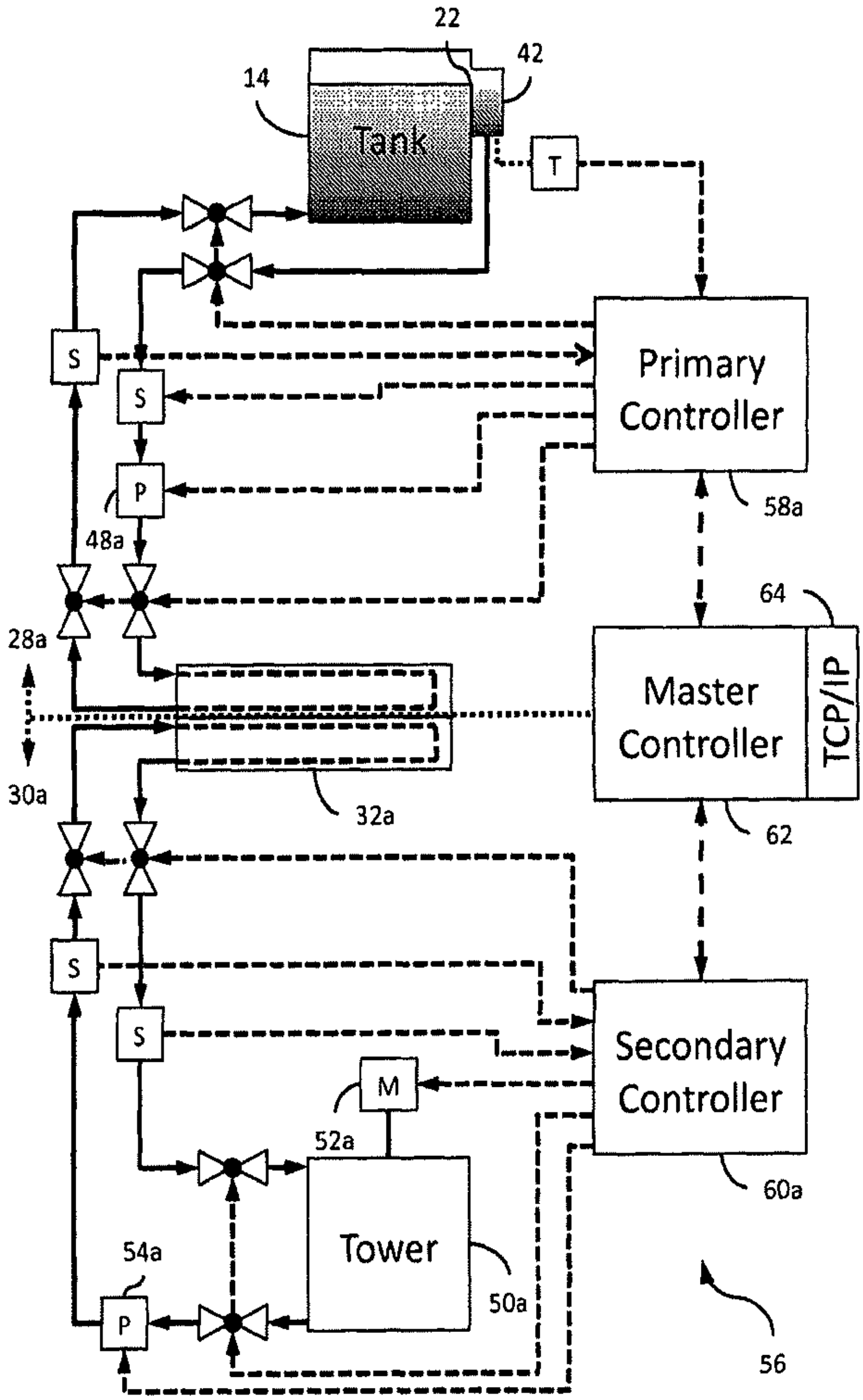

22
42
14
Tank
T
Primary
Controller
S
S
P
48a
58a
64
28a
Master
Controller
TCP/IP
30a
32a
62
S
S
M
Secondary
Controller
52a
60a
Tower
54a
P
50a
56

Fig. 13

APPLIANCE IMMERSION COOLING SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to the following Provisional Applications:

1. Ser. No. 61/737,200, filed 14 Dec. 2012 ("First Parent Provisional"); and
2. Ser. No. 61/832,211, filed 7 Jun. 2013 ("Second Parent Provisional");

and hereby claims benefit of the filing dates thereof pursuant to 37 CFR § 1.78(a)(4). (Collectively, "Parent Provisionals"). The subject matter of the Parent Provisionals, each in its entirety, is expressly incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to electrical appliance cooling systems, and, in particular, to an improved appliance immersion cooling system and method of operation.

2. Description of the Related Art

In general, in the descriptions that follow, we will italicize the first occurrence of each special term of art which should be familiar to those skilled in the art of immersion cooling systems. In addition, when we first introduce a term that we believe to be new or that we will use in a context that we believe to be new, we will bold the term and provide the definition that we intend to apply to that term.

U.S. Pat. No. 4,590,538, "Immersion Cooled High Density Electronic Assembly", Cray (filed 18 Nov. 1981 and issued 20 May 1986) ("Cray"), is an early example of an immersion system for cooling electronic components during normal operation. On information and belief, the machine disclosed therein was the Cray-2 super-computer ("Cray-2") manufactured by Cray Research, Inc. ("Cray Research"), of Chippewa Falls, Wis. Of particular interest to the present application is the description of the significant advantages resulting from using an electrically non-conductive or dielectric fluid to extract heat from electronic circuit assemblies during normal operation (see, e.g., col. 1, line 66-col. 2, line 29).

On information and belief, Cray Research released, in 1985, a marketing brochure entitled "The CRAY-2 Computer System" (a copy of which is submitted herewith) describing the Cray-2. Of particular interest in this brochure is the description therein of the significant advantages resulting from using a dielectric fluid to extract heat from electronic circuit assemblies during normal operation (see, pages 10 and 13).

U.S. Pat. No. 5,167,511, "High Density Interconnect Apparatus", Krajewski, et al. (issued 27 Nov. 1992) ("Krajewski"), discloses another example of an immersion system for cooling electronic components during normal operation (see, e.g., col. 2, lines 43-51). On information and belief, a machine implementing the Krajewski system was also marketed by Cray Research as a follow-on super-computer to the Cray-2.

One particular problem in the vertical-stack-type systems disclosed in the above references is the necessity of draining the cooling fluid whenever physical access to the electronic modules was required. In general, such an operation, besides being time consuming, requires the entire system to be switched off, especially if the component requiring attention is an essential element in the system architecture, such as the central processing unit ("CPU"). One possible solution to this problem is to immerse circuit assemblies vertically into a tank containing the cooling fluid such that each of the various assemblies can be withdrawn independently from the tank for servicing, replacement, upgrade, etc. One interesting example of such a system is disclosed in a web-presentation entitled "Puget Custom Computer's mineral-oil-cooled PC", by Nilay Patel ("Puget") (posted 12 May 2007 at 11:57 AM; a copy of which is submitted herewith). As noted by the author, the lack of supplemental apparatus in the Puget system to extract waste heat from the oil inherently limited its operating capabilities.

Another problem with the Cray Research systems in particular is the nature and cost of the chosen cooling fluid: fluorocarbon liquids. As is known, other dielectric fluids, such as mineral oil, have better heat transfer characteristics; of course, being an oil, the use thereof does represent a greater residue problem on modules that may be repairable. Notwithstanding, the Puget system implemented precisely this design choice.

US Patent Application Publication 2011/0132579, "Liquid Submerged, Horizontal Computer Appliance Rack and Systems and Method of Cooling such a Appliance Rack", Best, et al. ("Best"), discloses a appliance immersion tank system, include support apparatus for extracting waste heat from the tank cooling fluid and dissipating to the environment the heat so extracted. Although an improvement in several respects over the prior art discussed above, this system exhibits, inter alia, the following problems: generally non-uniform flow patterns through the several appliance slots within the tank, potentially resulting in uneven cooling across all slots; constricted dielectric fluid supply and return ports resulting in unnecessarily high fluid flow velocities at the respective points of connection to the tank; poor scalability; and inadequate attention to fail-soft operation.

The subject matter of all of the prior art references discussed above, each in its entirety, is expressly incorporated herein by reference.

We submit that what is needed is an improved appliance tank immersion system and method of operation. In particular, we submit that such a system should provide performance generally comparable to the best prior art techniques but more efficiently and effectively than known implementations of such prior art techniques.

BRIEF SUMMARY OF THE INVENTION

In accordance with a preferred embodiment of our invention, . . .

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Our invention may be more fully understood by a description of certain preferred embodiments in conjunction with the attached drawings in which:

FIG. **1** illustrates, in partial cut-away form, a front perspective of a tank module of an appliance immersion cooling system constructed in accordance with our invention;

FIG. **2** illustrates a rear perspective of the tank module shown in FIG. **1**;

FIG. **3** illustrates a close-up perspective of a detail A of FIG. **2**;

FIG. **4** illustrates a close-up perspective of a detail B of FIG. **2**;

FIG. **5** illustrates, in perspective view, several details of the tank shown in FIG. **1**, with special emphasis on the dielectric fluid recovery weir integrated into the long rear wall of the tank;

FIG. **6** illustrates, in cross-section view, the section C-C in FIG. **5**;

FIG. **7** illustrates, in perspective view, the plenum facility shown in FIG. **1**;

FIG. **8** illustrates, in top plan view, the orifice plate portion of the plenum facility shown in FIG. **7**;

FIG. **9** illustrates, in perspective view, the chamber portion of the plenum facility shown in FIG. **7**;

FIG. **10** illustrates, in top plan view, a plurality of appliance slots distributed vertically along, and extending transverse to, a long axis of the tank of FIG. **1**;

FIG. **11** illustrates, in longitudinal cross-sectional view, the plurality of appliance slots distributed vertically along, and extending transverse to, the long axis of the tank of FIG. **1**;

FIG. **12** illustrates, in flow schematic form, one instantiation of a flow arrangement suitable for implementing our invention; and

FIG. **13** illustrates, in control schematic form, one instantiation of a flow control facility suitable for implementing our invention.

In the drawings, similar elements will be similarly numbered whenever possible. However, this practice is simply for convenience of reference and to avoid unnecessary proliferation of numbers, and is not intended to imply or suggest that our invention requires identity in either function or structure in the several embodiments.

DETAILED DESCRIPTION OF THE INVENTION

Shown in FIG. **1** (front view) and FIG. **2** (rear view) is a tank module **10** adapted for use in an appliance immersion cooling system constructed in accordance with a preferred embodiment of our invention. For convenience of reference, we have illustrated in FIG. **1** the tank facility **12** of the immersion module **10** in partial cut-away to emphasize several important internal facilities; we have shown the tank facility **12** in isolation in FIG. **5**. In general, the tank facility **12** comprises: a tank **14** adapted to immerse in a dielectric fluid a plurality of electrical appliances **16**, e.g., contemporary computer servers (see, e.g., FIG. **11**), each in a respective appliance slot **18***a* distributed vertically along, and extending transverse to, a long axis of the tank **14** (see, generally, FIG. **10**); an appliance rack facility **20** of convention design adapted to suspend the appliances **16** (see, e.g., FIG. **11**) in respective appliance slots **18** (see, FIG. **10**); a weir **22** (best seen in isolation in FIG. **5** and FIG. **6**), integrated horizontally into one long wall of the tank **14** adjacent all appliance slots **18**, and adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each of the appliance slots **18**; an interconnect panel facility **24** attached to the upper rear edge of the tank **14** and adapted to mount various appliance power distribution equipment, cable interconnection panels and the like (none shown); and a cover **26** adapted to be opened and closed from the front of the tank **14** (and which may include a translucent portion to allow viewing of the interior of the tank **14** when in the closed position). In addition to the tank facility **12**, the immersion module **10** comprises: a primary circulation facility **28** (portions of which are shown in both FIG. **1** and FIG. **2**); a secondary fluid circulation facility **30** (of which only redundant heat exchangers **32***a* and **32***b* are shown in FIG. **2**); and control equipment cabinets **34***a* and **34***b*, each adapted to accommodate the module status and control equipment associated with a respective one of the primary circulation facilities **28***a* and **28***b* (see, FIG. **13**).

As can be best seen in FIG. **2**, the primary circulation facility **28** (comprising redundant sub-facilities **28***a* and **28***b*) comprises both passive (conduits, couplers, etc.) and active (valves, pumps, sensors, etc.) components; a subset of the passive components are shared, whereas, in general, the active components are duplicated and adapted to cooperate in operation as separate, redundant sub-facilities. Excluding the tank **14**, the primary shared component is the plenum facility **36** (see, FIG. **1** and FIG. **7**) comprising an orifice plate **36***a* (see, FIG. **8**) and a plenum chamber **36***b* (see, FIG. **9**). As can be seen in FIG. **1**, cooled dielectric fluid is pumped into both ends of the plenum facility **36** via a shared distribution header **38** (see, FIG. **2** and FIG. **3**). In general, the plenum plate **36***a* comprises at least one row of orifices vertically aligned with each appliance slot **18***a*, with the dimensions and flow rates of each set being adapted to provide substantially equal flow of the dielectric fluid upwardly into each appliance slot **18***a*. Preferably, each appliance slot **18***a* is supplied via several rows of orifices, thus generally tending to reduce the volume of the dielectric fluid exiting each orifice and to make the flow of dielectric fluid more uniform upwardly through the appliance slots **18**. One further shared component is the dielectric fluid recovery facility **40** (FIG. **2**) comprising a dielectric fluid recovery reservoir **42** (see, FIG. **3**, FIG. **4** and FIG. **13**) positioned vertically beneath the overflow lip of the weir **22** and adapted smoothly to receive the dielectric fluid as it flows over the weir **22**; the dielectric fluid recovery reservoir **42** is further adapted to allow the recovered fluid to be removed from the reservoir **42** via redundant recovery ports **44***a* and **44***b* (only port **44***a* can be seen in FIG. **2** as the port **44***b* is obscured by the heat exchanger **32***a*; but see FIG. **12**). As can be seen in both FIG. **3** and FIG. **4**, we consider it desirable to provide a vortex breaker at the input of each of the recovery ports **44**. Also, we provide a removable recovery reservoir cover **46** adapted to also cover a major portion of the distribution header **38**; note that, in both FIG. **2** and FIG. **3**, we have illustrated the reservoir cover **46** in a partially raised orientation so as to better depict details that would otherwise be obscured. Note that we have constructed the reservoir **42** such that the average height of dielectric fluid above the recovery ports **44** develops sufficient hydrostatic head to meet the requirements of the pumps **48**, while also tending to minimize the likelihood of breaking suction during normal operation.

At this point in the primary circulation facility **28**, we provide fully redundant sub-facilities **28***a* and **28***b*, each comprising a primary circulation pump (**48***a* and **48***b*) and associated passive and active components which, collectively, provide the motive power for circulating the dielectric fluid through the shared components and tank **14**. As can be generally seen, each of these sub-facilities **28***a* and **28***b* is adapted to recover the dielectric fluid exiting the tank **14** via the weir **22**, re-pressurize the recovered fluid, pass the re-pressurized fluid through a respective one of the heat exchangers **32***a* and **32***b*, and then back to the plenum facility **36** via the header **38**.

Shown in FIG. **12** is one flow arrangement suitable for integrating our tank module **10** into a fully redundant, appliance immersion cooling system, comprising the primary circulation facility **28** and the secondary fluid circulation facility **30**. In general, the secondary fluid circulation facility **30** comprises redundant secondary circulation sub-

facilities **30***a* and **30***b*, each of which is adapted to circulate a cooling fluid, e.g., treated water, through the respective heat exchanger **32***a* and **32***b* to extract heat from dielectric fluid counter-circulating therethrough and to dissipate to the environment the heat so extracted. In the illustrated embodiment, each of the secondary fluid sub-facilities **30***a* and **30***b* comprise conventional cooling towers **50***a* (including fan facility **52***a*) and **50***b* (including fan facility **52***b*), and secondary circulation pumps **54***a* and **54***b*. To facilitate flexible operation in installations including multiple immersion modules **10** in combination with a plurality of secondary circulation sub-facilities **30**, a common header arrangement can be implemented as illustrated in the secondary fluid circulation loop, with flow control valves located at key flow control points as is known.

Shown in FIG. **13** is a control facility **56** adapted to monitor and control the operation of both the immersion module **10** (including all active components of the primary circulation facility **28**), and the secondary fluid circulation facility **30**. As will be evident to those skilled in this art, efficient operation of our immersion module **10** requires continuous monitoring and control of several essential operating parameters, including fluidic temperatures, pressures, conductivity and pH at several points in the primary and secondary circulation loops. Although the several sensory and control functions can be implemented using traditional dedicated hardware components, we prefer to employ at least one programmable logic controller ("PLC"), commercially available from any of a number of respected vendors, e.g., the Allen-Bradley brand of PLCs from Rockwell Automation, Inc. In the instantiation illustrated in FIG. **13**, we have depicted: a primary controller **58***a* adapted to monitor and control the operation of the primary circulation sub-facility **28***a* as a function of the temperature of the dielectric fluid in the tank **14**; a secondary controller **60***a* adapted to monitor and control the operation of the secondary fluid circulation sub-facility **30***a* as a function of the temperature of the dielectric fluid flowing through the heat exchanger **32***a*; and a master controller **62** adapted to coordinate the activities of the primary controller **58***a* and secondary controller **60***a*. As can be seen, we have incorporated into the primary circulation sub-facility **28***a*: supply and return sensors, including a temperature probe, T, inserted into a thermowell (not shown) installed in the bottom of the reservoir **42** adjacent a respective return port **44***a* (note that, in FIG. **4**, only one of the holes that receive the thermowells is illustrated, but both holes are illustrated in FIG. **12**); a pair of sensor facilities, S, which may sense temperature, pressure and conductivity, as deemed desirable); and return (and, if desired, supply) flow control valves and controls for the primary circulation pump **48***a*; of course, a redundant set of these components exists for the primary circulation sub-facility **28***b*. In general, the goal is to maintain the temperature of the dielectric fluid in the tank **14** between a predetermined minimum temperature and a predetermined maximum temperature.

As noted above, we have provided separate control equipment cabinets **34***a* and **34***b*, each adapted to accommodate the several components comprising a respective one of the primary controllers **58***a* and **58***b*. For convenience of access, we prefer to co-locate with each of the cooling towers **50** a protective housing (not shown) for the respective secondary controller **60**. Of course, the control facility **56** can be instantiated as a single, multi-module PLC facility, with similar or other combinations of monitoring devices as deemed most appropriate for a particular installation. Alternatively, one or more, and perhaps all, of the functions performed by the controllers **58**, **60** and **62** may be implemented in the form of dedicated application-specific software executing on a conventional computer platform having the appropriate resources; indeed, it would be entirely feasible to implement the entire control facility **56** on a server **16** installed in a tank **14**.

One desirable enhancement that we recommend is a remote control facility, implemented, e.g., via the master controller **62** (or by way of a direct, per-controller interface), adapted to facilitate remote monitoring of system status (e.g., temperatures, pressures, etc.) and control over system control parameters (e.g., temperature and pressure limits, etc.) to the primary controllers **58** and secondary controllers **60**. For example, using a conventional data communication hardware module **64**, e.g., an ethernet card implementing the TCP/IP protocol, a modern web browser can be adapted to provide a graphical user interface ("GUI") with sufficient functionality to facilitate monitoring and control of an entire installation from a remote location. Such a GUI may be implemented using any of a number of programming paradigms, e.g., PHP, .NET and the like.

Operational control of redundant, continuous process flow systems is generally well known. Preferable, each of the several redundant sub-facilities are routinely activated to assure current functionality, and to allow the inactive sub-facility to be serviced according to an established schedule. We believe this continuous rotation of system resources to be so important that we recommend switching the sub-facilities at least once, and preferably, several times, per day; although this is possible to implement manually, we prefer to enable the master controller **62** to control the sequencing of the several switch-over operations. One further aspect of this sophistication in control is the ability to perform stress testing of the several sub-systems under controlled conditions so as to assure appropriate response to real-time emergencies.

In our First Parent Provisional, we have disclosed an alternate embodiment comprising an appliance immersion tank facility wherein the function of the plenum facility **36** is performed by a manifold facility comprising a ladder-arrangement of tubular spray bars, each bar of which supplies dielectric fluid to a respective appliance slot. As we noted, one particular advantage of this arrangement is that individual spray bars may be shut off if the respective appliance slot is not occupied and, thus, save energy. To further increase energy efficiency, we have provided optional vertical flow barriers adapted to partition the tank into an active portion, having active appliances, and a stagnant portion, having no active appliances. One further enhancement we disclosed is the provision of temperature sensors per appliance slot, such that the flow rate through each spray bar can be dynamically varied as a function of the temperature of the dielectric fluid exiting the respective slot. Other operative configurations will be readily perceived by those skilled in this art.

In a manner analogous to the embodiment described in our First Parent Provisional, it would be advantageous, from an energy point of view, to provide a plurality of flow barrier plates **66** (shown by way of example only in FIG. **11**), each adapted to be attached to the top of the plenum facility **36** so as substantially to block the flow of the dielectric fluid through the row(s) of orifices in the plenum plate **36***a* corresponding to at least a respective one of the appliance slots **18***a*; an elastomeric layer (not shown) could be provided on the interface surface of the plate(s) **66** to enhance the sealing effect. Such an arrangement would allow the total flow through the plenum facility **36** to be adjusted, in the

field, as a function of the actual number of active appliances **16** in the tank **14**. Further, this arrangement can incorporate a relocatable vertical baffle plate **68** (see FIG. **11**) adapted substantially to partition the tank **14** into an active portion **14***a* containing the active appliances **16** and an inactive portion **14***b* containing no appliances (or at least no active appliances **16**); preferably, the baffle plate **68** is adapted to be mounted in the appliance rack facility **28** in a manner similar to an actual appliance **16** (the baffle plate **68** need not fully block the flow of dielectric fluid between the active portion **14***a* and inactive portion **14***b*, but only significantly impede the flow between these portions). Note that, in the example scenario illustrated in FIG. **11**, we have shown one possible arrangement of a total of 8 active appliances **16** distributed across 16 appliance slots **18***a* so as to spread the total heat load across adjacent empty slots **18***a*. Such an optimal arrangement is possible only if less than a majority of the available appliance slots **18***a* are occupied by an active appliance **16**. Clearly, such optional adjunct facilities enhance flexibility in operation, accommodating dynamic adjustment of the flow rates in the primary circulation sub-facilities **28***a* and **28***b* under variable heat loads, while providing opportunities to conserve energy that might otherwise be expended moving the dielectric fluid through the inactive portion **14***b* of the tank **14**. Other operative configurations will be readily perceived by those skilled in this art.

In our Second Parent Provisional, we have disclosed another embodiment comprising a more conventional, less-modularized instantiation with appropriate flow and control facilities. In this embodiment, we chose to implement tank clusters, comprising, e.g., **4** appliance immersion tank facilities, with substantially all of the other equipment being constructed from stand-alone, commercially available components. Such an arrangement offers greater opportunities to select and install improved components, or to add enhancements to the installation, as deemed desirable after initial installation. Other operative configurations will be readily perceived by those skilled in this art.

As we noted above with reference to the embodiment illustrated in FIG. **12**, the secondary flow header facility is well adapted to allow any secondary circulation sub-facility **30** to be connected to any active heat exchanger **32**. Such a facility provides great flexibility in dealing with unusual system conditions, especially in installations wherein the secondary circulation sub-facilities **30***a* and **30***b* are each sized to support a cluster of tank modules **10**. Imagine, for example, that, while one of the secondary circulation facilities **30**, say sub-facility **30***a*, is being serviced, the activities of the set of appliances **16** in one tank **14** in the cluster are higher than normal, resulting in a rise in temperature in that tank **14** above the desired maximum. In response, the master controller **62** can direct Primary Controllers **58***a* and **58***b* assigned to tank **14** to operate both of the primary circulation sub-facilities **28***a* and **28***b* simultaneously, i.e., in parallel. Using the secondary flow header facility, the heat being extracted by both of the heat exchangers **32***a* and **32***b* may be dissipated using the resources of the single on-line secondary circulation sub-facility **30***b*. Thus, one clear advantage of this alternate embodiment is the ability dynamically to perform load balancing across all system resources. Other operative configurations to support subsystem load balancing will be readily perceived by those skilled in this art.

Preferably, one or more filters (not shown) are included in the flow path through each of the primary circulation sub-facilities **28***a* and **28***b* to remove any particulates or other undesirable foreign matter that may have been picked up by the dielectric fluid on its passage though the entire primary circulation facility **28**; chemical sensors may also be provided to detect the presence of unexpected chemicals that may indicate failure of sub-components within one of the appliances **16**. Similar components, such as pH sensors, may also included in the secondary fluid circulation facility **30**.

As can be seen generally in FIG. **1**, we provide a pair of low dielectric fluid level sensors **70***a* and **70***b* adapted to trigger an alarm signal in the event that, for whatever reason, the level of the dielectric fluid in the tank **14** drops below a predetermined minimum level. Additionally, the responsive primary controller **58** can initiate other actions to address the detected problem, including activating audio alarms, transmitting electronic alert signals and the like.

To solve a reciprocal problem, namely leakage from an external portion of the primary circulation loop **28** resulting in the dielectric fluid in the tank **14** being back-siphoned through the plenum facility **36**, we recommend incorporating a siphon breaker **72** (see, FIG. **1**) in the supply pipe at a predetermined location well above the plenum facility **36** but somewhat below the level of the weir **24**. Such a siphon breaker can be as simple as a relatively small diameter hole **72** drilled through the supply pipe at the selected location; due to the relatively high viscosity of the dielectric fluid, even when heated, any resulting leakage during normal operation will be relatively insignificant. Other operative responses to address these and other unusual fluidic conditions will be readily perceived by those skilled in this art.

As is known (see, e.g., Best), many conventional, commercially available electrical/electronic appliances include components that will not function correctly if immersed in a dielectric fluid, especially one as viscous as mineral oil: cooling fans and rotating media disk drives. In general, all cooling fans are unnecessary in an immersion cooling system and can be simply removed. The media drives, however, are usually necessary for normal appliance operation. One option is to remove each drive, totally seal the drive against fluid entry, and reinstall the now-sealed drive (pre-sealed drives are also available). Another option is to remove the drive and mount it on the interconnect panel facility **24**; typically special cabling will be required to re-attach the drive to the internal appliance socket. Yet another option is to replace the rotating media drive with a solid-state drive having no moving components. Other operative configurations will be readily perceived by those skilled in this art.

It will be recognized that, in all of the embodiments described herein, emphasis was placed on minimizing the total volume of the dielectric fluid circulating throughout each immersion module **10**. We submit that the key concept here is to move the secondary fluid to the point of heat exchange with the primary fluid, rather than to move the primary fluid to the point of heat exchange with the secondary fluid. Thus, in our preferred embodiment, all of the essential components of the primary circulation facility **28** are tightly co-located with the tank **14** so as to form a highly-integrated module. Further, our placement of the reservoir **42** outside of (but immediately adjacent to) the tank **14** tends to reduce the total volume of the dielectric fluid (as opposed to the alternative arrangement we proposed in our First Provisional, wherein a recovery trough was disposed within the tank **14**); then, we positioned the components comprising the primary circulation sub-facilities **28** so as to be vertically beneath the footprint of the reservoir **42**. In addition to conserving valuable floor space in a typical data center installation, the resulting modular configuration facilitates both easy initial installation and subsequent

upgrade to efficiently satisfy increasing data center workloads. Indeed, our invention greatly enhances system scalability, a key concern to data center operators. Finally, our system-wide redundancy substantially assures fail-soft operation during periods of unusual environmental conditions, infrastructure instability or political unrest.

Although we have described our invention in the context of particular embodiments, one of ordinary skill in this art will readily realize that many modifications may be made in such embodiments to adapt either to specific implementations. By way of example, it will take but little effort to adapt our invention for use with electronic appliances other than contemporary servers; and to adjust the dimensions of the appliance accommodation slots accordingly. Similarly, practitioners in the art will readily recognize that other, known secondary circulation facilities may be employed effectively, including forced air, vapor compression systems, earth-water sink loops, waste heat recovery and recycling systems, and the like (see, e.g., the several alternatives discussed in Best). Further, the several elements described above may be implemented using any of the various known manufacturing methodologies, and, in general, be adapted so as to be operable under either hardware or software control or some combination thereof, as is known in this art.

Thus it is apparent that we have provided an improved system and method of operation for immersion cooling of appliances and the like. In particular, we submit that such a method and apparatus provides performance generally comparable to the best prior art techniques but more efficiently and effectively than known implementations of such prior art techniques.

What we claim is:

1. An appliance immersion cooling system comprising:

a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising:

a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot; and;

a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir;

a primary circulation facility adapted to circulate the dielectric fluid through the tank, comprising:

a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot;

a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted; and

a control facility adapted to coordinate the operation of the primary and secondary fluid circulation facilities as a function of the temperature of the dielectric fluid in the tank.

2. The system of claim **1** wherein the tank and primary circulation facility comprise a highly-integrated module.

3. The system of claim **1** wherein the tank further comprises:

an interconnect panel facility adapted to mount appliance support equipment.

4. The system of claim **1** wherein the primary circulation facility further comprises:

at least first and second primary circulation sub-facilities, each adapted to operate independently to circulate the dielectric fluid through the tank;

wherein the control facility is further adapted to coordinate the operation of the first and second primary circulation sub-facilities and the secondary fluid circulation facilities so to maintain the temperature of the dielectric fluid in the tank substantially between a predetermined minimum temperature and a predetermined maximum temperature.

5. The system of claim **1** wherein the control facility further comprises a communication facility adapted to facilitate monitoring and control of the control facility from a remote location.

6. A tank module adapted for use in an appliance immersion cooling system, the tank module comprising:

a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising:

a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot; and;

a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir;

a primary circulation facility adapted to circulate the dielectric fluid through the tank, comprising:

a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot; and

a control facility adapted to control the operation of the primary fluid circulation facility as a function of the temperature of the dielectric fluid in the tank.

7. The module of claim **6** wherein the tank and primary circulation facility comprise a highly-integrated module.

8. The module of claim **6** wherein the tank further comprises:

an interconnect panel facility adapted to mount appliance support equipment.

9. The module of claim **6** wherein the primary circulation facility further comprises:

at least first and second primary circulation sub-facilities, each adapted to operate independently to circulate the dielectric fluid through the tank;

wherein the control facility is further adapted to coordinate the operation of the first and second primary circulation sub-facilities so to maintain the temperature of the dielectric fluid in the tank substantially between a predetermined minimum temperature and a predetermined maximum temperature.

10. The module of claim **6** wherein the control facility further comprises a communication facility adapted to facilitate monitoring and control of the control facility from a remote location.

11. A tank module (**10**) adapted for use in an appliance immersion cooling system, the tank module comprising:

a tank (**12**) adapted to immerse in a dielectric fluid a plurality of electrical appliances (**16**), each in a respective appliance slot (**18**) distributed vertically along, and extending transverse to, a long wall of the tank (**10**), the tank (**10**) comprising:

a weir **22**, integrated horizontally into the long wall of the tank (**10**) adjacent all appliance slots (**18**),

adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot (**18**);

a primary circulation facility (**28**) adapted to circulate the dielectric fluid through the tank (**10**), comprising:

a plenum (**36**), positioned adjacent the bottom of the tank (**10**), adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot (**18**); and

a control facility (**58**) adapted to control the operation of the primary fluid circulation facility (**28**) as a function of the temperature of the dielectric fluid in the tank (**10**).

12. The tank module of claim **11** wherein the tank further comprises:

an interconnect panel facility (**24**) adapted to mount appliance support equipment.

13. The module of claim **11** wherein the primary circulation facility further comprises:

at least first and second primary circulation sub-facilities (**28***a*, **28***b*), each adapted to operate independently to circulate the dielectric fluid through the tank;

wherein the control facility is further adapted to coordinate the operation of the first and second primary circulation sub-facilities so to maintain the temperature of the dielectric fluid in the tank substantially between a predetermined minimum temperature and a predetermined maximum temperature.

14. The module of claim **11** wherein the control facility further comprises a communication facility (**62**, **64**) adapted to facilitate monitoring and control of the control facility from a remote location.

15. An appliance immersion cooling system comprising a tank module according to any one of the preceding claims **11** through **14**.

16. An appliance immersion cooling system according to claim **15**, further comprising:

a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted.

* * * * *

EXHIBIT B

US010820446B2

(12) **United States Patent**
Boyd et al.

(10) **Patent No.: US 10,820,446 B2**
(45) **Date of Patent: *Oct. 27, 2020**

(54) **APPLIANCE IMMERSION COOLING SYSTEM**

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(72) Inventors: **Christopher L. Boyd**, Austin, TX (US); **James P. Koen**, Round Rock, TX (US); **David Christopher Laguna**, Austin, TX (US); **Thomas R. Turner**, Georgetown, TX (US); **Kenneth D. Swinden**, Hutto, TX (US); **Mario Conti Garcia**, Austin, TX (US); **John Charles Tribou**, Austin, TX (US)

(73) Assignee: **Midas Green Technologies, LLC**, Austin, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/243,732**

(22) Filed: **Jan. 9, 2019**

(65) **Prior Publication Data**

US 2019/0200482 A1 Jun. 27, 2019

Related U.S. Application Data

(63) Continuation of application No. 14/355,533, filed as application No. PCT/US2013/075126 on Dec. 13, 2013, now Pat. No. 10,405,457.

(Continued)

(51) **Int. Cl.**
H01L 23/44 (2006.01)
H05K 7/20 (2006.01)

(52) **U.S. Cl.**
CPC ***H05K 7/20236*** (2013.01); ***H01L 23/44*** (2013.01); ***H05K 7/20272*** (2013.01)

(58) **Field of Classification Search**
CPC H05K 7/20236; H05K 7/20272; H05K 7/20327; H01L 23/44
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,406,244 A * 10/1968 Oktay G06F 1/20 174/15.1
4,590,538 A * 5/1986 Cray, Jr. H05K 7/20236 361/700

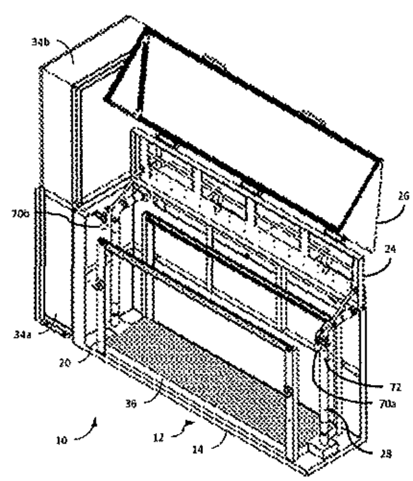
(Continued)

Primary Examiner — Devon Russell
(74) *Attorney, Agent, or Firm* — Jeffrey Van Myers

(57) **ABSTRACT**

A appliance immersion tank system comprising: a generally rectangular tank adapted to immerse in a dielectric fluid a plurality of appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, the long axis of the tank; a primary circulation facility adapted to circulate the dielectric fluid through the tank; a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted; and a control facility adapted to coordinate the operation of the primary and secondary fluid circulation facilities as a function of the temperature of the dielectric fluid in the tank. A plenum, positioned adjacent the bottom of the tank, is adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot. A weir, integrated horizontally into a long wall of the tank, is adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot. All active and most passive components of both the primary and secondary fluid circulation facilities, and the control facility are fully redundant, and are adapted automatically to operate in a fail-soft mode.

10 Claims, 7 Drawing Sheets



Related U.S. Application Data

(60) Provisional application No. 61/832,211, filed on Jun. 7, 2013.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,167,511	A *	12/1992	Krajewski	H01R 4/01 361/785
5,297,621	A *	3/1994	Taraci	G01R 31/2891 165/104.13
2005/0259402	A1*	11/2005	Yasui	H02M 7/003 361/716
2006/0126292	A1*	6/2006	Pfahnl	H05K 7/20563 361/695
2006/0274501	A1*	12/2006	Miller	G01R 31/2863 361/690
2011/0075353	A1*	3/2011	Attlesey	H05K 7/20345 361/679.47
2011/0132579	A1*	6/2011	Best	H05K 7/20763 165/104.31
2011/0240281	A1*	10/2011	Avery	G05D 23/1917 165/287

* cited by examiner

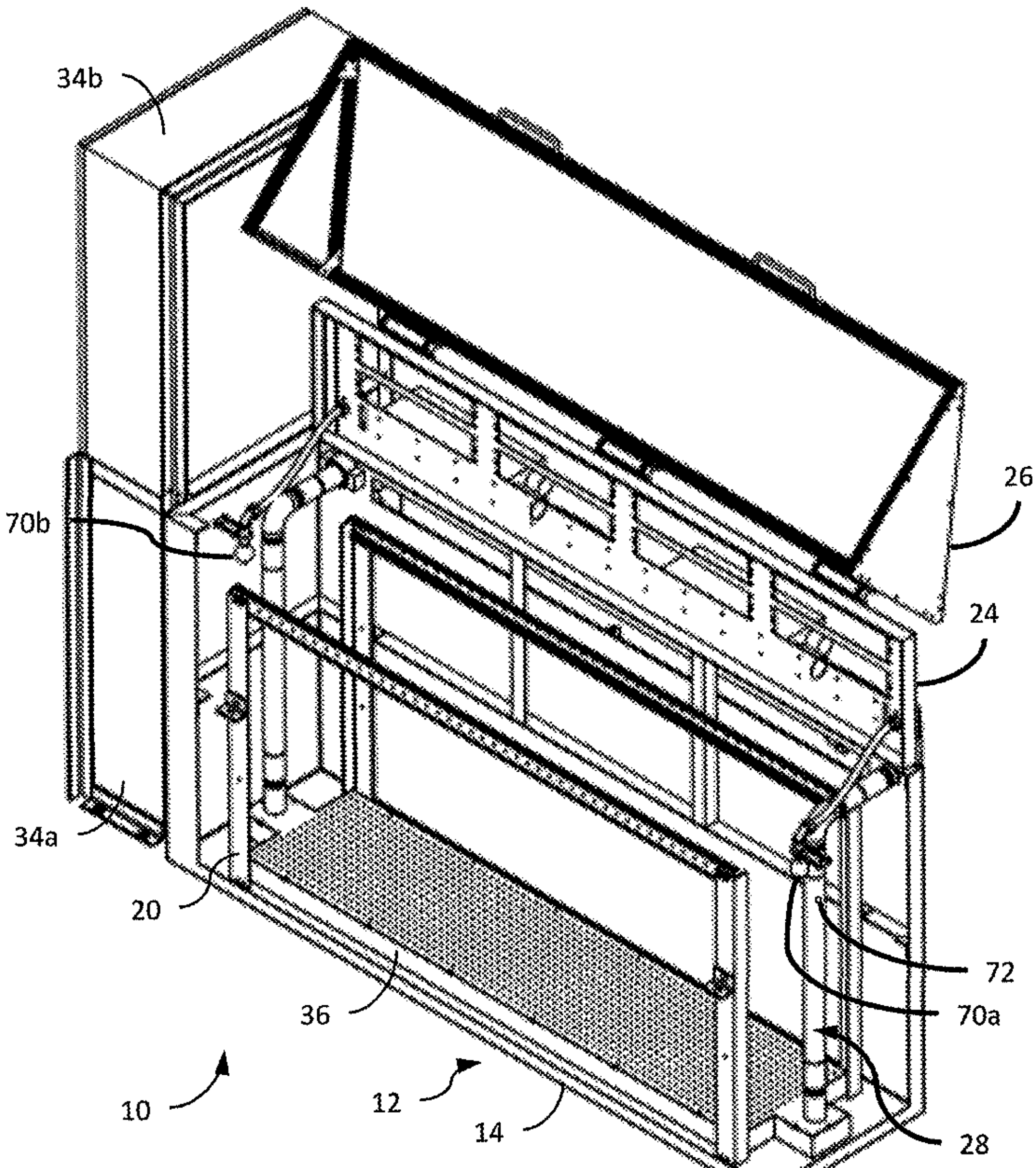


Fig. 1

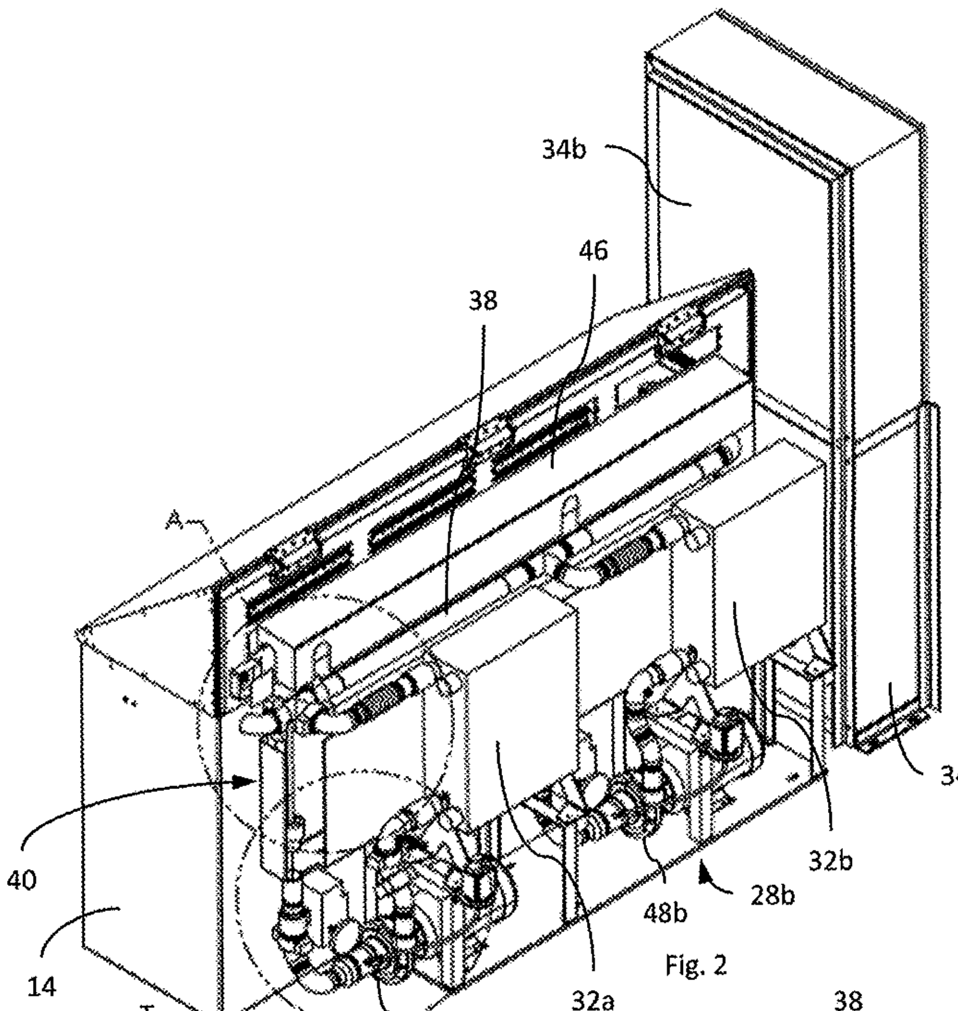


Fig. 2

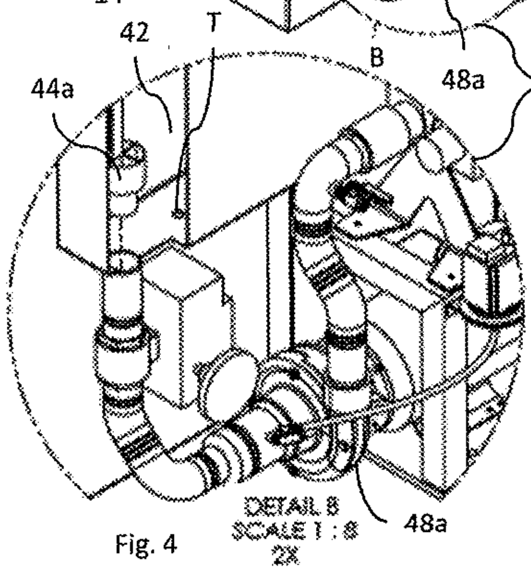


Fig. 4

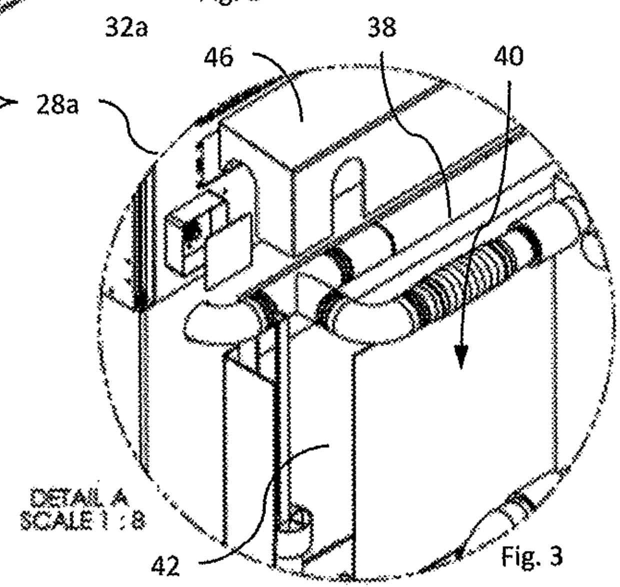


Fig. 3

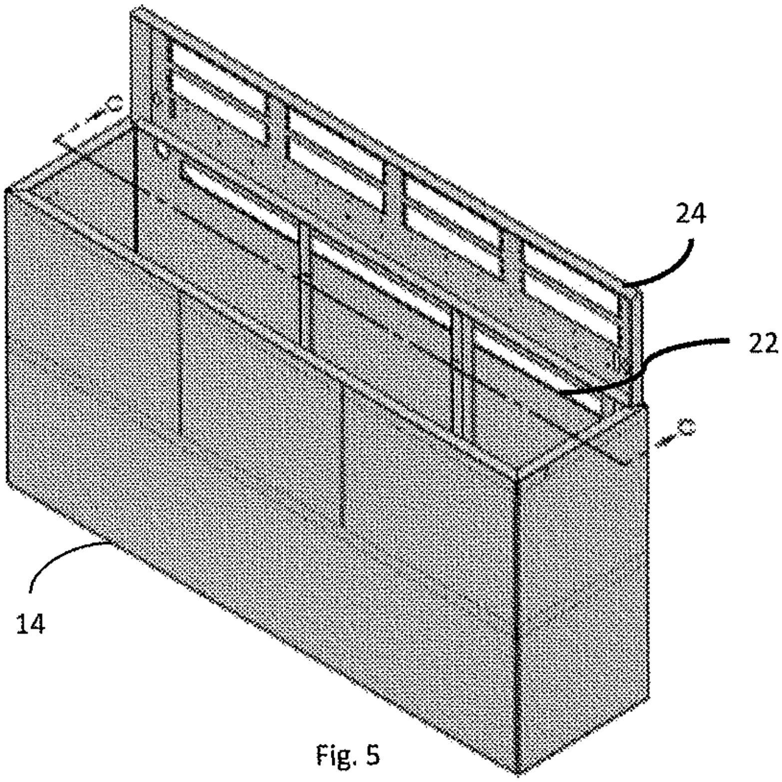
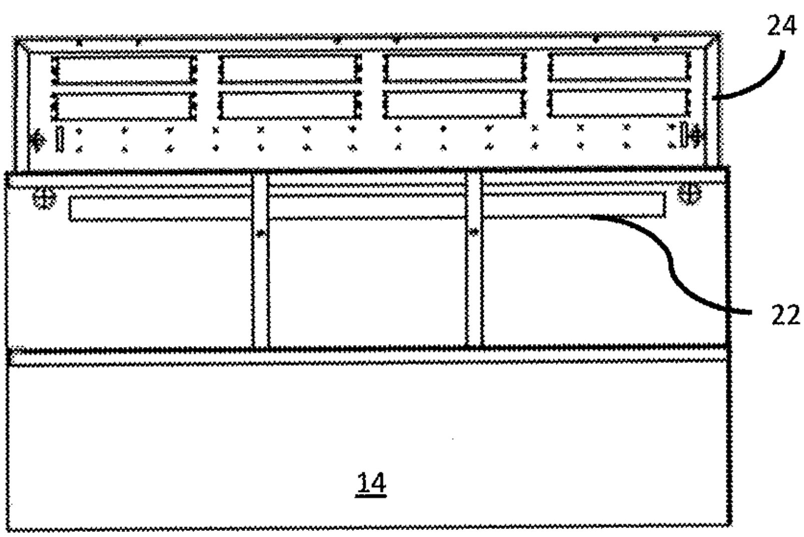


Fig. 5



Section C-C
Fig. 6

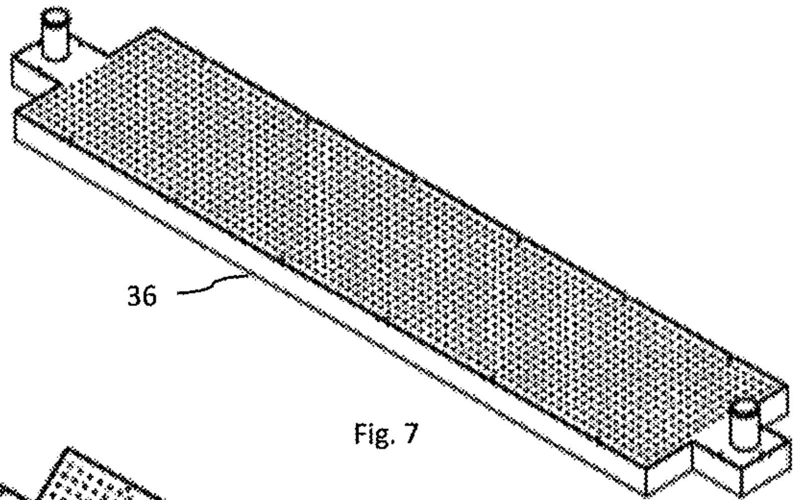


Fig. 7

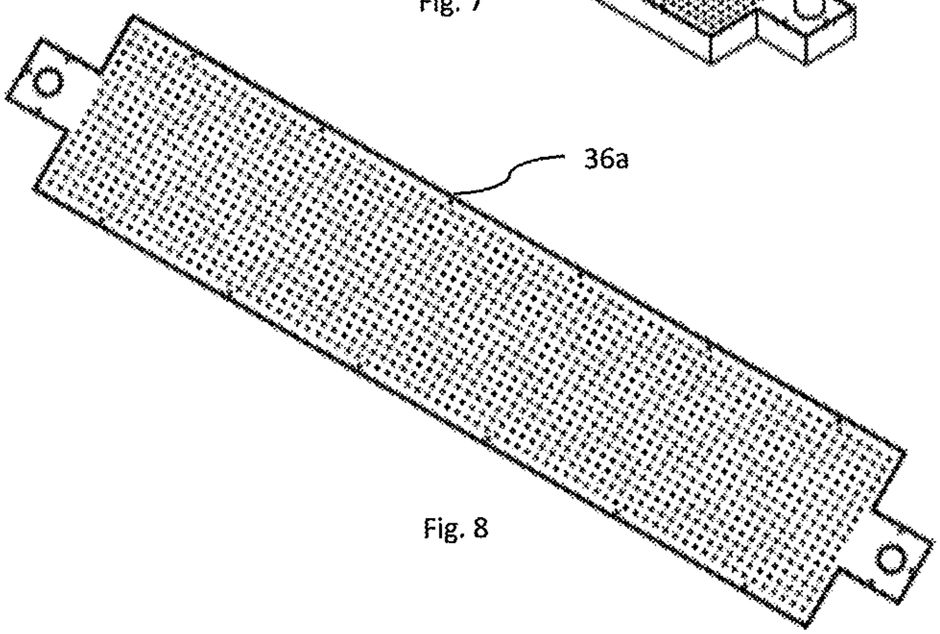


Fig. 8

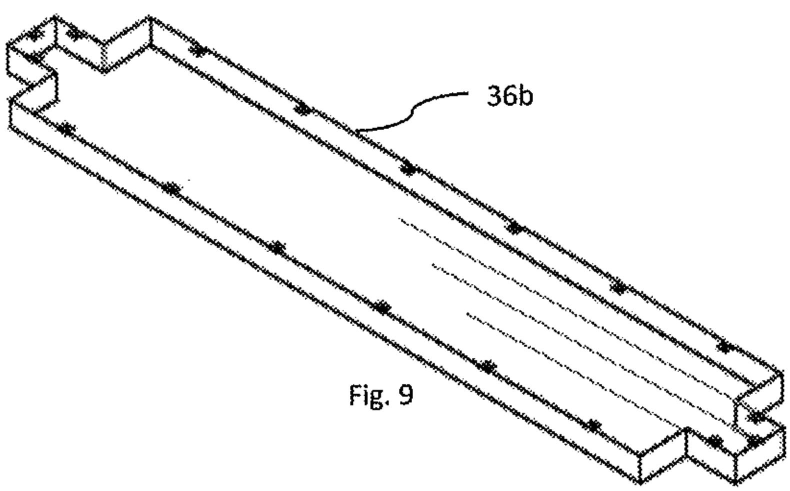


Fig. 9

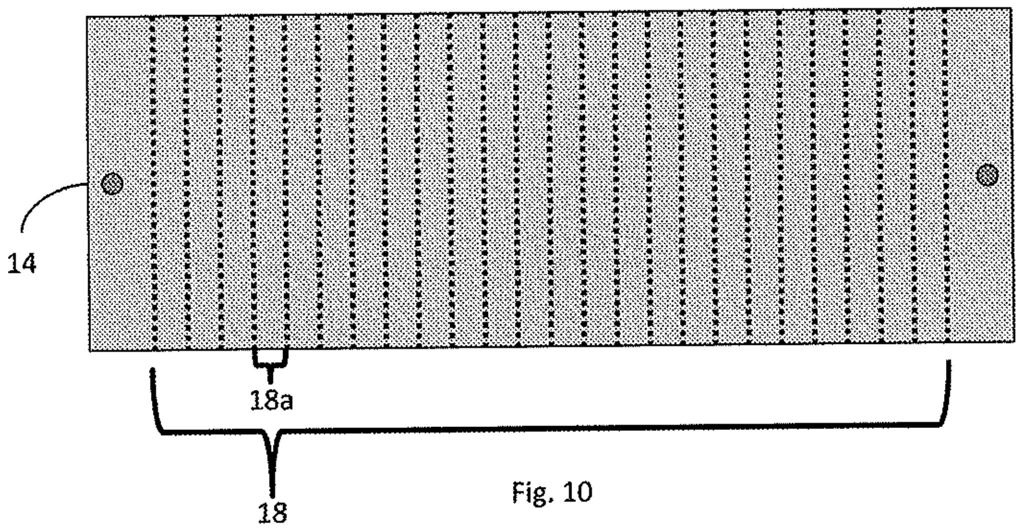


Fig. 10

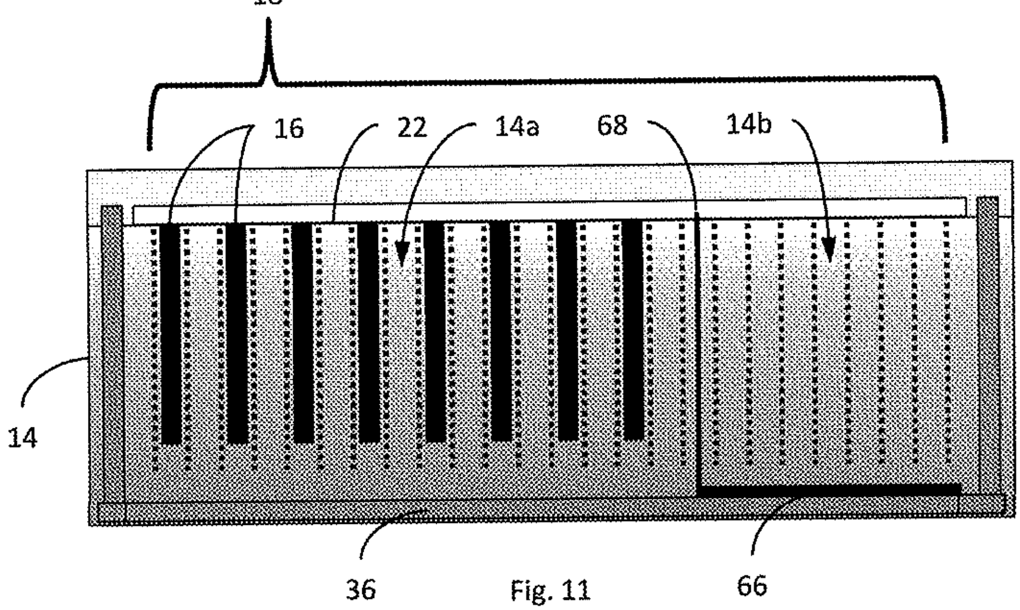


Fig. 11

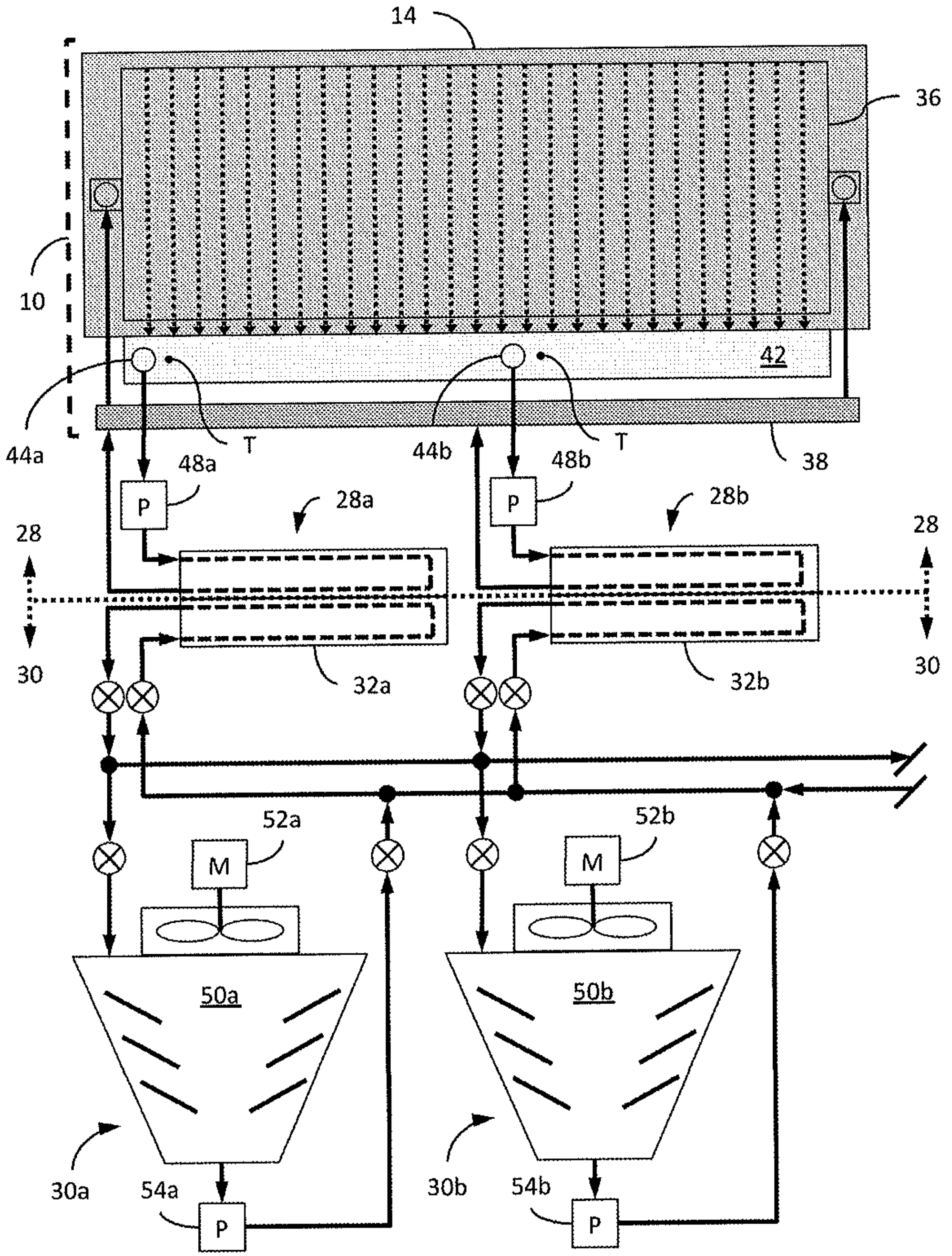

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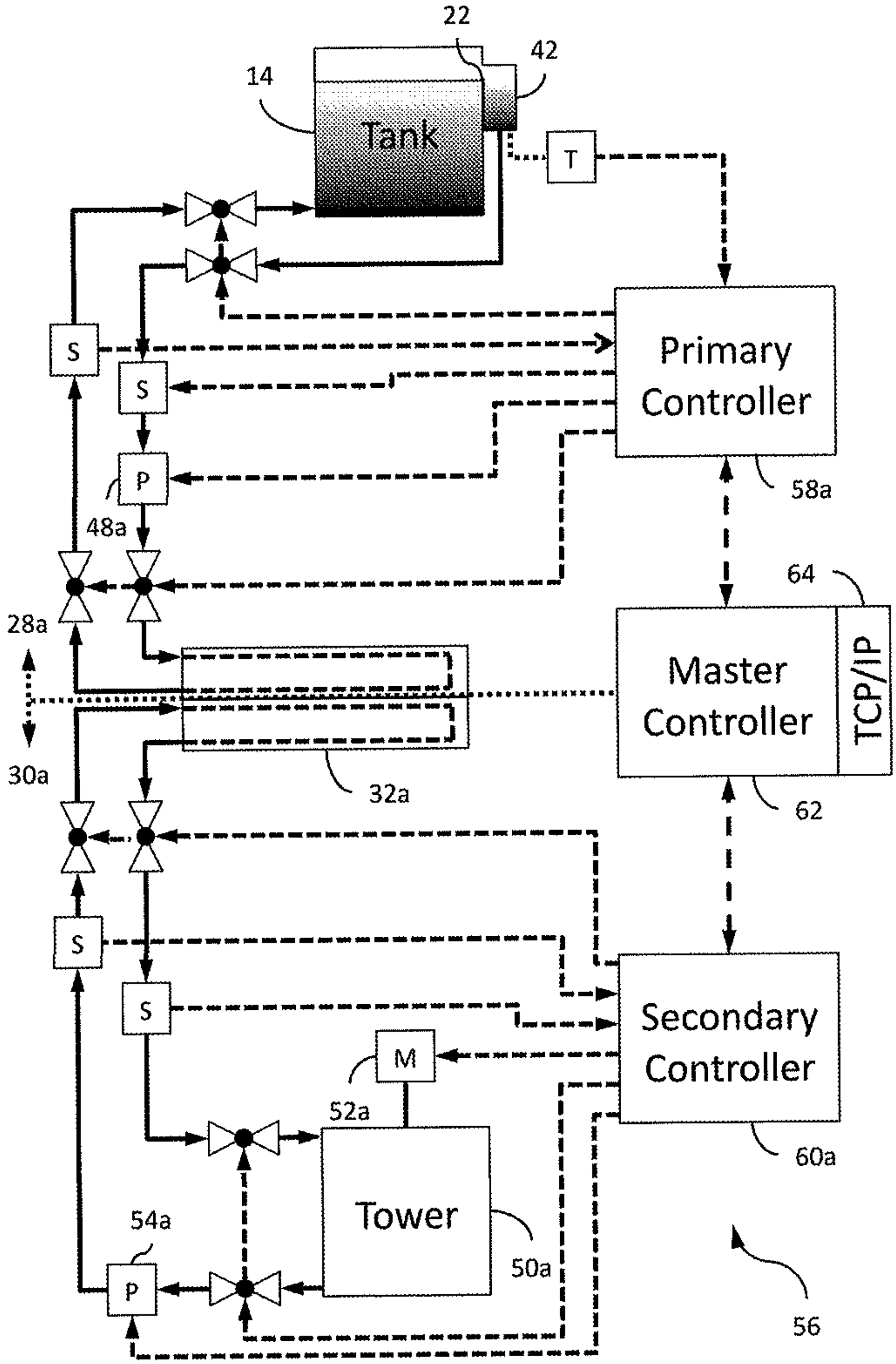
Fig. 12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62
S
S
M
Secondary Controller
52a
60a
Tower
54a
P
50a
56

Fig. 13

APPLIANCE IMMERSION COOLING SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to the following Provisional applications:

1. Ser. No. 61/737,200, filed 14 Dec. 2012 ("First Parent Provisional"); and
2. Ser. No. 61/832,211, filed 7 Jun. 2013 ("Second Parent Provisional");

and hereby claims benefit of the filing dates thereof pursuant to 37 CFR § 1.78(a)(4). (Collectively, "Parent Provisionals"). The subject matter of the Parent Provisionals, each in its entirety, is expressly incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to electrical appliance cooling systems, and, in particular, to an improved appliance immersion cooling system and method of operation.

2. Description of the Related Art

In general, in the descriptions that follow, we will italicize the first occurrence of each special term of art which should be familiar to those skilled in the art of immersion cooling systems. In addition, when we first introduce a term that we believe to be new or that we will use in a context that we believe to be new, we will bold the term and provide the definition that we intend to apply to that term.

U.S. Pat. No. 4,590,538, "Immersion Cooled High Density Electronic Assembly", Cray (filed 18 Nov. 1981 and issued 20 May 1986) ("Cray"), is an early example of an immersion system for cooling electronic components during normal operation. On information and belief, the machine disclosed therein was the Cray-2 super-computer ("Cray-2") manufactured by Cray Research, Inc. ("Cray Research"), of Chippewa Falls, Wis. Of particular interest to the present application is the description of the significant advantages resulting from using an electrically non-conductive or dielectric fluid to extract heat from electronic circuit assemblies during normal operation (see, e.g., col. 1, line 66—col. 2, line 29).

On information and belief, Cray Research released, in 1985, a marketing brochure entitled "The CRAY-2 Computer System" (a copy of which is submitted herewith) describing the Cray-2. Of particular interest in this brochure is the description therein of the significant advantages resulting from using a dielectric fluid to extract heat from electronic circuit assemblies during normal operation (see, pages 10 and 13).

U.S. Pat. No. 5,167,511, "High Density Interconnect Apparatus", Krajewski, et al. (issued 27 Nov. 1992) ("Krajewski"), discloses another example of an immersion system for cooling electronic components during normal operation (see, e.g., col. 2, lines 43-51). On information and belief, a machine implementing the Krajewski system was also marketed by Cray Research as a follow-on super-computer to the Cray-2.

One particular problem in the vertical-stack-type systems disclosed in the above references is the necessity of draining the cooling fluid whenever physical access to the electronic

modules was required. In general, such an operation, besides being time consuming, requires the entire system to be switched off, especially if the component requiring attention is an essential element in the system architecture, such as the central processing unit ("CPU"). One possible solution to this problem is to immerse circuit assemblies vertically into a tank containing the cooling fluid such that each of the various assemblies can be withdrawn independently from the tank for servicing, replacement, upgrade, etc. One interesting example of such a system is disclosed in a web-presentation entitled "Puget Custom Computer's mineral-oil-cooled PC", by Nilay Patel ("Puget") (posted 12 May 2007 at 11:57 AM; a copy of which is submitted herewith). As noted by the author, the lack of supplemental apparatus in the Puget system to extract waste heat from the oil inherently limited its operating capabilities.

Another problem with the Cray Research systems in particular is the nature and cost of the chosen cooling fluid: fluorocarbon liquids. As is known, other dielectric fluids, such as mineral oil, have better heat transfer characteristics; of course, being an oil, the use thereof does represent a greater residue problem on modules that may be repairable. Notwithstanding, the Puget system implemented precisely this design choice.

US Patent Application Publication 2011/0132579, "Liquid Submerged, Horizontal Computer Appliance Rack and Systems and Method of Cooling such a Appliance Rack", Best, et al. ("Best"), discloses a appliance immersion tank system, include support apparatus for extracting waste heat from the tank cooling fluid and dissipating to the environment the heat so extracted. Although an improvement in several respects over the prior art discussed above, this system exhibits, inter alia, the following problems: generally non-uniform flow patterns through the several appliance slots within the tank, potentially resulting in uneven cooling across all slots; constricted dielectric fluid supply and return ports resulting in unnecessarily high fluid flow velocities at the respective points of connection to the tank; poor scalability; and inadequate attention to fail-soft operation.

The subject matter of all of the prior art references discussed above, each in its entirety, is expressly incorporated herein by reference.

We submit that what is needed is an improved appliance tank immersion system and method of operation. In particular, we submit that such a system should provide performance generally comparable to the best prior art techniques but more efficiently and effectively than known implementations of such prior art techniques.

BRIEF SUMMARY OF THE INVENTION

In accordance with a preferred embodiment of our invention, . . .

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Our invention may be more fully understood by a description of certain preferred embodiments in conjunction with the attached drawings in which:

FIG. **1** illustrates, in partial cut-away form, a front perspective of a tank module of an appliance immersion cooling system constructed in accordance with our invention;

FIG. **2** illustrates a rear perspective of the tank module shown in FIG. **1**;

FIG. **3** illustrates a close-up perspective of a detail A of FIG. **2**;

FIG. **4** illustrates a close-up perspective of a detail B of FIG. **2**;

FIG. **5** illustrates, in perspective view, several details of the tank shown in FIG. **1**, with special emphasis on the dielectric fluid recovery weir integrated into the long rear wall of the tank;

FIG. **6** illustrates, in cross-section view, the section C-C in FIG. **5**;

FIG. **7** illustrates, in perspective view, the plenum facility shown in FIG. **1**;

FIG. **8** illustrates, in top plan view, the orifice plate portion of the plenum facility shown in FIG. **7**;

FIG. **9** illustrates, in perspective view, the chamber portion of the plenum facility shown in FIG. **7**;

FIG. **10** illustrates, in top plan view, a plurality of appliance slots distributed vertically along, and extending transverse to, a long axis of the tank of FIG. **1**;

FIG. **11** illustrates, in longitudinal cross-sectional view, the plurality of appliance slots distributed vertically along, and extending transverse to, the long axis of the tank of FIG. **1**;

FIG. **12** illustrates, in flow schematic form, one instantiation of a flow arrangement suitable for implementing our invention; and

FIG. **13** illustrates, in control schematic form, one instantiation of a flow control facility suitable for implementing our invention.

In the drawings, similar elements will be similarly numbered whenever possible. However, this practice is simply for convenience of reference and to avoid unnecessary proliferation of numbers, and is not intended to imply or suggest that our invention requires identity in either function or structure in the several embodiments.

DETAILED DESCRIPTION OF THE INVENTION

Shown in FIG. **1** (front view) and FIG. **2** (rear view) is a tank module **10** adapted for use in an appliance immersion cooling system constructed in accordance with a preferred embodiment of our invention. For convenience of reference, we have illustrated in FIG. **1** the tank facility **12** of the immersion module **10** in partial cut-away to emphasize several important internal facilities; we have shown the tank facility **12** in isolation in FIG. **5**. In general, the tank facility **12** comprises: a tank **14** adapted to immerse in a dielectric fluid a plurality of electrical appliances **16**, e.g., contemporary computer servers (see, e.g., FIG. **11**), each in a respective appliance slot **18***a* distributed vertically along, and extending transverse to, a long axis of the tank **14** (see, generally, FIG. **10**); an appliance rack facility **20** of convention design adapted to suspend the appliances **16** (see, e.g., FIG. **11**) in respective appliance slots **18** (see, FIG. **10**); a weir **22** (best seen in isolation in FIG. **5** and FIG. **6**), integrated horizontally into one long wall of the tank **14** adjacent all appliance slots **18**, and adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each of the appliance slots **18**; an interconnect panel facility **24** attached to the upper rear edge of the tank **14** and adapted to mount various appliance power distribution equipment, cable interconnection panels and the like (none shown); and a cover **26** adapted to be opened and closed from the front of the tank **14** (and which may include a translucent portion to allow viewing of the interior of the tank **14** when in the closed position). In addition to the tank facility **12**, the immersion module **10** comprises: a primary circulation facility **28** (portions of which are shown in both FIG. **1** and FIG. **2**); a secondary fluid circulation facility **30** (of which only redundant heat exchangers **32***a* and **32***b* are shown in FIG. **2**); and control equipment cabinets **34***a* and **34***b*, each adapted to accommodate the module status and control equipment associated with a respective one of the primary circulation facilities **28***a* and **28***b* (see, FIG. **13**).

As can be best seen in FIG. **2**, the primary circulation facility **28** (comprising redundant sub-facilities **28***a* and **28***b*) comprises both passive (conduits, couplers, etc.) and active (valves, pumps, sensors, etc.) components; a subset of the passive components are shared, whereas, in general, the active components are duplicated and adapted to cooperate in operation as separate, redundant sub-facilities. Excluding the tank **14**, the primary shared component is the plenum facility **36** (see, FIG. **1** and FIG. **7**) comprising an orifice plate **36***a* (see, FIG. **8**) and a plenum chamber **36***b* (see, FIG. **9**). As can be seen in FIG. **1**, cooled dielectric fluid is pumped into both ends of the plenum facility **36** via a shared distribution header **38** (see, FIG. **2** and FIG. **3**). In general, the plenum plate **36***a* comprises at least one row of orifices vertically aligned with each appliance slot **18***a*, with the dimensions and flow rates of each set being adapted to provide substantially equal flow of the dielectric fluid upwardly into each appliance slot **18***a*. Preferably, each appliance slot **18***a* is supplied via several rows of orifices, thus generally tending to reduce the volume of the dielectric fluid exiting each orifice and to make the flow of dielectric fluid more uniform upwardly through the appliance slots **18**. One further shared component is the dielectric fluid recovery facility **40** (FIG. **2**) comprising a dielectric fluid recovery reservoir **42** (see, FIG. **3**, FIG. **4** and FIG. **13**) positioned vertically beneath the overflow lip of the weir **22** and adapted smoothly to receive the dielectric fluid as it flows over the weir **22**; the dielectric fluid recovery reservoir **42** is further adapted to allow the recovered fluid to be removed from the reservoir **42** via redundant recovery ports **44***a* and **44***b* (only port **44***a* can be seen in FIG. **2** as the port **44***b* is obscured by the heat exchanger **32***a*; but see FIG. **12**). As can be seen in both FIG. **3** and FIG. **4**, we consider it desirable to provide a vortex breaker at the input of each of the recovery ports **44**. Also, we provide a removable recovery reservoir cover **46** adapted to also cover a major portion of the distribution header **38**; note that, in both FIG. **2** and FIG. **3**, we have illustrated the reservoir cover **46** in a partially raised orientation so as to better depict details that would otherwise be obscured. Note that we have constructed the reservoir **42** such that the average height of dielectric fluid above the recovery ports **44** develops sufficient hydrostatic head to meet the requirements of the pumps **48**, while also tending to minimize the likelihood of breaking suction during normal operation.

At this point in the primary circulation facility **28**, we provide fully redundant sub-facilities **28***a* and **28***b*, each comprising a primary circulation pump (**48***a* and **48***b*) and associated passive and active components which, collectively, provide the motive power for circulating the dielectric fluid through the shared components and tank **14**. As can be generally seen, each of these sub-facilities **28***a* and **28***b* is adapted to recover the dielectric fluid exiting the tank **14** via the weir **22**, re-pressurize the recovered fluid, pass the re-pressurized fluid through a respective one of the heat exchangers **32***a* and **32***b*, and then back to the plenum facility **36** via the header **38**.

Shown in FIG. **12** is one flow arrangement suitable for integrating our tank module **10** into a fully redundant, appliance immersion cooling system, comprising the primary circulation facility **28** and the secondary fluid circu-

lation facility **30**. In general, the secondary fluid circulation facility **30** comprises redundant secondary circulation sub-facilities **30***a* and **30***b*, each of which is adapted to circulate a cooling fluid, e.g., treated water, through the respective heat exchanger **32***a* and **32***b* to extract heat from dielectric fluid counter-circulating therethrough and to dissipate to the environment the heat so extracted. In the illustrated embodiment, each of the secondary fluid sub-facilities **30***a* and **30***b* comprise conventional cooling towers **50***a* (including fan facility **52***a*) and **50***b* (including fan facility **52***b*), and secondary circulation pumps **54***a* and **54***b*. To facilitate flexible operation in installations including multiple immersion modules **10** in combination with a plurality of secondary circulation sub-facilities **30**, a common header arrangement can be implemented as illustrated in the secondary fluid circulation loop, with flow control valves located at key flow control points as is known.

Shown in FIG. **13** is a control facility **56** adapted to monitor and control the operation of both the immersion module **10** (including all active components of the primary circulation facility **28**), and the secondary fluid circulation facility **30**. As will be evident to those skilled in this art, efficient operation of our immersion module **10** requires continuous monitoring and control of several essential operating parameters, including fluidic temperatures, pressures, conductivity and pH at several points in the primary and secondary circulation loops. Although the several sensory and control functions can be implemented using traditional dedicated hardware components, we prefer to employ at least one programmable logic controller ("PLC"), commercially available from any of a number of respected vendors, e.g., the Allen-Bradley brand of PLCs from Rockwell Automation, Inc. In the instantiation illustrated in FIG. **13**, we have depicted: a primary controller **58***a* adapted to monitor and control the operation of the primary circulation sub-facility **28***a* as a function of the temperature of the dielectric fluid in the tank **14**; a secondary controller **60***a* adapted to monitor and control the operation of the secondary fluid circulation sub-facility **30***a* as a function of the temperature of the dielectric fluid flowing through the heat exchanger **32***a*; and a master controller **62** adapted to coordinate the activities of the primary controller **58***a* and secondary controller **60***a*. As can be seen, we have incorporated into the primary circulation sub-facility **28***a*: supply and return sensors, including a temperature probe, T, inserted into a thermowell (not shown) installed in the bottom of the reservoir **42** adjacent a respective return port **44***a* (note that, in FIG. **4**, only one of the holes that receive the thermowells is illustrated, but both holes are illustrated in FIG. **12**); a pair of sensor facilities, S, which may sense temperature, pressure and conductivity, as deemed desirable); and return (and, if desired, supply) flow control valves and controls for the primary circulation pump **48***a*; of course, a redundant set of these components exists for the primary circulation sub-facility **28***b*. In general, the goal is to maintain the temperature of the dielectric fluid in the tank **14** between a predetermined minimum temperature and a predetermined maximum temperature.

As noted above, we have provided separate control equipment cabinets **34***a* and **34***b*, each adapted to accommodate the several components comprising a respective one of the primary controllers **58***a* and **58***b*. For convenience of access, we prefer to co-locate with each of the cooling towers **50** a protective housing (not shown) for the respective secondary controller **60**. Of course, the control facility **56** can be instantiated as a single, multi-module PLC facility, with similar or other combinations of monitoring devices as deemed most appropriate for a particular installation. Alternatively, one or more, and perhaps all, of the functions performed by the controllers **58**, **60** and **62** may be implemented in the form of dedicated application-specific software executing on a conventional computer platform having the appropriate resources; indeed, it would be entirely feasible to implement the entire control facility **56** on a server **16** installed in a tank **14**.

One desirable enhancement that we recommend is a remote control facility, implemented, e.g., via the master controller **62** (or by way of a direct, per-controller interface), adapted to facilitate remote monitoring of system status (e.g., temperatures, pressures, etc.) and control over system control parameters (e.g., temperature and pressure limits, etc.) to the primary controllers **58** and secondary controllers **60**. For example, using a conventional data communication hardware module **64**, e.g., an ethernet card implementing the TCP/IP protocol, a modern web browser can be adapted to provide a graphical user interface ("GUI") with sufficient functionality to facilitate monitoring and control of an entire installation from a remote location. Such a GUI may be implemented using any of a number of programming paradigms, e.g., PHP, .NET and the like.

Operational control of redundant, continuous process flow systems is generally well known. Preferable, each of the several redundant sub-facilities are routinely activated to assure current functionality, and to allow the inactive sub-facility to be serviced according to an established schedule. We believe this continuous rotation of system resources to be so important that we recommend switching the sub-facilities at least once, and preferably, several times, per day; although this is possible to implement manually, we prefer to enable the master controller **62** to control the sequencing of the several switch-over operations. One further aspect of this sophistication in control is the ability to perform stress testing of the several sub-systems under controlled conditions so as to assure appropriate response to real-time emergencies.

In our First Parent Provisional, we have disclosed an alternate embodiment comprising an appliance immersion tank facility wherein the function of the plenum facility **36** is performed by a manifold facility comprising a ladder-arrangement of tubular spray bars, each bar of which supplies dielectric fluid to a respective appliance slot. As we noted, one particular advantage of this arrangement is that individual spray bars may be shut off if the respective appliance slot is not occupied and, thus, save energy. To further increase energy efficiency, we have provided optional vertical flow barriers adapted to partition the tank into an active portion, having active appliances, and a stagnant portion, having no active appliances. One further enhancement we disclosed is the provision of temperature sensors per appliance slot, such that the flow rate through each spray bar can be dynamically varied as a function of the temperature of the dielectric fluid exiting the respective slot. Other operative configurations will be readily perceived by those skilled in this art.

In a manner analogous to the embodiment described in our First Parent Provisional, it would be advantageous, from an energy point of view, to provide a plurality of flow barrier plates **66** (shown by way of example only in FIG. **11**), each adapted to be attached to the top of the plenum facility **36** so as substantially to block the flow of the dielectric fluid through the row(s) of orifices in the plenum plate **36***a* corresponding to at least a respective one of the appliance slots **18***a*; an elastomeric layer (not shown) could be provided on the interface surface of the plate(s) **66** to enhance

the sealing effect. Such an arrangement would allow the total flow through the plenum facility **36** to be adjusted, in the field, as a function of the actual number of active appliances **16** in the tank **14**. Further, this arrangement can incorporate a relocatable vertical baffle plate **68** (see FIG. **11**) adapted substantially to partition the tank **14** into an active portion **14***a* containing the active appliances **16** and an inactive portion **14***b* containing no appliances (or at least no active appliances **16**); preferably, the baffle plate **68** is adapted to be mounted in the appliance rack facility **28** in a manner similar to an actual appliance **16** (the baffle plate **68** need not fully block the flow of dielectric fluid between the active portion **14***a* and inactive portion **14***b*, but only significantly impede the flow between these portions). Note that, in the example scenario illustrated in FIG. **11**, we have shown one possible arrangement of a total of 8 active appliances **16** distributed across **16** appliance slots **18***a* so as to spread the total heat load across adjacent empty slots **18***a*. Such an optimal arrangement is possible only if less than a majority of the available appliance slots **18***a* are occupied by an active appliance **16**. Clearly, such optional adjunct facilities enhance flexibility in operation, accommodating dynamic adjustment of the flow rates in the primary circulation sub-facilities **28***a* and **28***b* under variable heat loads, while providing opportunities to conserve energy that might otherwise be expended moving the dielectric fluid through the inactive portion **14***b* of the tank **14**. Other operative configurations will be readily perceived by those skilled in this art.

In our Second Parent Provisional, we have disclosed another embodiment comprising a more conventional, less-modularized instantiation with appropriate flow and control facilities. In this embodiment, we chose to implement tank clusters, comprising, e.g., 4 appliance immersion tank facilities, with substantially all of the other equipment being constructed from stand-alone, commercially available components. Such an arrangement offers greater opportunities to select and install improved components, or to add enhancements to the installation, as deemed desirable after initial installation. Other operative configurations will be readily perceived by those skilled in this art.

As we noted above with reference to the embodiment illustrated in FIG. **12**, the secondary flow header facility is well adapted to allow any secondary circulation sub-facility **30** to be connected to any active heat exchanger **32**. Such a facility provides great flexibility in dealing with unusual system conditions, especially in installations wherein the secondary circulation sub-facilities **30***a* and **30***b* are each sized to support a cluster of tank modules **10**. Imagine, for example, that, while one of the secondary circulation facilities **30**, say sub-facility **30***a*, is being serviced, the activities of the set of appliances **16** in one tank **14** in the cluster are higher than normal, resulting in a rise in temperature in that tank **14** above the desired maximum. In response, the master controller **62** can direct Primary Controllers **58***a* and **58***b* assigned to tank **14** to operate both of the primary circulation sub-facilities **28***a* and **28***b* simultaneously, i.e., in parallel. Using the secondary flow header facility, the heat being extracted by both of the heat exchangers **32***a* and **32***b* may be dissipated using the resources of the single on-line secondary circulation sub-facility **30***b*. Thus, one clear advantage of this alternate embodiment is the ability dynamically to perform load balancing across all system resources. Other operative configurations to support subsystem load balancing will be readily perceived by those skilled in this art.

Preferably, one or more filters (not shown) are included in the flow path through each of the primary circulation sub-facilities **28***a* and **28***b* to remove any particulates or other undesirable foreign matter that may have been picked up by the dielectric fluid on its passage though the entire primary circulation facility **28**; chemical sensors may also be provided to detect the presence of unexpected chemicals that may indicate failure of sub-components within one of the appliances **16**. Similar components, such as pH sensors, may also included in the secondary fluid circulation facility **30**.

As can be seen generally in FIG. **1**, we provide a pair of low dielectric fluid level sensors **70***a* and **70***b* adapted to trigger an alarm signal in the event that, for whatever reason, the level of the dielectric fluid in the tank **14** drops below a predetermined minimum level. Additionally, the responsive primary controller **58** can initiate other actions to address the detected problem, including activating audio alarms, transmitting electronic alert signals and the like.

To solve a reciprocal problem, namely leakage from an external portion of the primary circulation loop **28** resulting in the dielectric fluid in the tank **14** being back-siphoned through the plenum facility **36**, we recommend incorporating a siphon breaker **72** (see, FIG. **1**) in the supply pipe at a predetermined location well above the plenum facility **36** but somewhat below the level of the weir **24**. Such a siphon breaker can be as simple as a relatively small diameter hole **72** drilled through the supply pipe at the selected location; due to the relatively high viscosity of the dielectric fluid, even when heated, any resulting leakage during normal operation will be relatively insignificant. Other operative responses to address these and other unusual fluidic conditions will be readily perceived by those skilled in this art.

As is known (see, e.g., Best), many conventional, commercially available electrical/electronic appliances include components that will not function correctly if immersed in a dielectric fluid, especially one as viscous as mineral oil: cooling fans and rotating media disk drives. In general, all cooling fans are unnecessary in an immersion cooling system and can be simply removed. The media drives, however, are usually necessary for normal appliance operation. One option is to remove each drive, totally seal the drive against fluid entry, and reinstall the now-sealed drive (pre-sealed drives are also available). Another option is to remove the drive and mount it on the interconnect panel facility **24**; typically special cabling will be required to re-attach the drive to the internal appliance socket. Yet another option is to replace the rotating media drive with a solid-state drive having no moving components. Other operative configurations will be readily perceived by those skilled in this art.

It will be recognized that, in all of the embodiments described herein, emphasis was placed on minimizing the total volume of the dielectric fluid circulating throughout each immersion module **10**. We submit that the key concept here is to move the secondary fluid to the point of heat exchange with the primary fluid, rather than to move the primary fluid to the point of heat exchange with the secondary fluid. Thus, in our preferred embodiment, all of the essential components of the primary circulation facility **28** are tightly co-located with the tank **14** so as to form a highly-integrated module. Further, our placement of the reservoir **42** outside of (but immediately adjacent to) the tank **14** tends to reduce the total volume of the dielectric fluid (as opposed to the alternative arrangement we proposed in our First Provisional, wherein a recovery trough was disposed within the tank **14**); then, we positioned the components comprising the primary circulation sub-facilities **28** so as to be vertically beneath the footprint of the reservoir

42. In addition to conserving valuable floor space in a typical data center installation, the resulting modular configuration facilitates both easy initial installation and subsequent upgrade to efficiently satisfy increasing data center workloads. Indeed, our invention greatly enhances system scalability, a key concern to data center operators. Finally, our system-wide redundancy substantially assures fail-soft operation during periods of unusual environmental conditions, infrastructure instability or political unrest.

Although we have described our invention in the context of particular embodiments, one of ordinary skill in this art will readily realize that many modifications may be made in such embodiments to adapt either to specific implementations. By way of example, it will take but little effort to adapt our invention for use with electronic appliances other than contemporary servers; and to adjust the dimensions of the appliance accommodation slots accordingly. Similarly, practitioners in the art will readily recognize that other, known secondary circulation facilities may be employed effectively, including forced air, vapor compression systems, earth-water sink loops, waste heat recovery and recycling systems, and the like (see, e.g., the several alternatives discussed in Best). Further, the several elements described above may be implemented using any of the various known manufacturing methodologies, and, in general, be adapted so as to be operable under either hardware or software control or some combination thereof, as is known in this art.

Thus it is apparent that we have provided an improved system and method of operation for immersion cooling of appliances and the like. In particular, we submit that such a method and apparatus provides performance generally comparable to the best prior art techniques but more efficiently and effectively than known implementations of such prior art techniques.

What we claim is:

1. An appliance immersion cooling system comprising:
a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising:
a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot;
a primary circulation facility adapted to circulate the dielectric fluid through the tank, comprising:
a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot;
a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted; and
a control facility adapted to coordinate the operation of the primary and secondary fluid circulation facilities as a function of the temperature of the dielectric fluid in the tank.

2. The system of claim 1 wherein the tank and primary circulation facility comprise a tightly co-located module.

3. The system of claim 1 wherein the tank further comprises:
an interconnect panel facility adapted to mount appliance support equipment.

4. The system of claim 1 wherein the primary circulation facility further comprises:
at least first and second primary circulation sub-facilities, each adapted to operate independently to circulate the dielectric fluid through the tank;
wherein the control facility is further adapted to coordinate the operation of the first and second primary circulation sub-facilities and the secondary fluid circulation facilities so to maintain the temperature of the dielectric fluid in the tank substantially between a predetermined minimum temperature and a predetermined maximum temperature.

5. The system of claim 1 wherein the control facility further comprises a communication facility adapted to facilitate monitoring and control of the control facility from a remote location.

6. A tank module adapted for use in an appliance immersion cooling system, the tank module comprising:
a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising:
a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot;
a primary circulation facility adapted to circulate the dielectric fluid through the tank, comprising:
a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot; and
a control facility adapted to control the operation of the primary fluid circulation facility as a function of the temperature of the dielectric fluid in the tank.

7. The module of claim 6 wherein the tank and primary circulation facility comprise a tightly co-located module.

8. The module of claim 6 wherein the tank further comprises:
an interconnect panel facility adapted to mount appliance support equipment.

9. The module of claim 6 wherein the primary circulation facility further comprises:
at least first and second primary circulation sub-facilities, each adapted to operate independently to circulate the dielectric fluid through the tank;
wherein the control facility is further adapted to coordinate the operation of the first and second primary circulation sub-facilities so to maintain the temperature of the dielectric fluid in the tank substantially between a predetermined minimum temperature and a predetermined maximum temperature.

10. The module of claim 6 wherein the control facility further comprises a communication facility adapted to facilitate monitoring and control of the control facility from a remote location.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 10,820,446 B2
APPLICATION NO. : 16/243732
DATED : October 27, 2020
INVENTOR(S) : Christopher L. Boyd et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page

In Item [60], replace "Provisional application No. 61/832,211, filed on Jun. 7, 2013." with --Provisional application No. 61/737,200, filed on Dec. 14, 2012; and provisional application No. 61/832,211, filed Jun. 7, 2013.--.

Signed and Sealed this
Fourteenth Day of December, 2021

Drew Hirshfeld
Performing the Functions and Duties of the
Under Secretary of Commerce for Intellectual Property and
Director of the United States Patent and Trademark Office

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 10,820,446 B2
APPLICATION NO. : 16/243732
DATED : October 27, 2020
INVENTOR(S) : Christopher L. Boyd et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

This certificate supersedes the Certificate of Correction issued on December 14, 2021. The Certificate which issued on December 14, 2021 is vacated because the certificate improperly added an application to the benefit claim in the "Related U.S. Application" section in the title page of U.S. Patent No. 10,820,446 B2. The Certificate of Correction which issued on December 14, 2021 was published in error and should not have been for this patent.

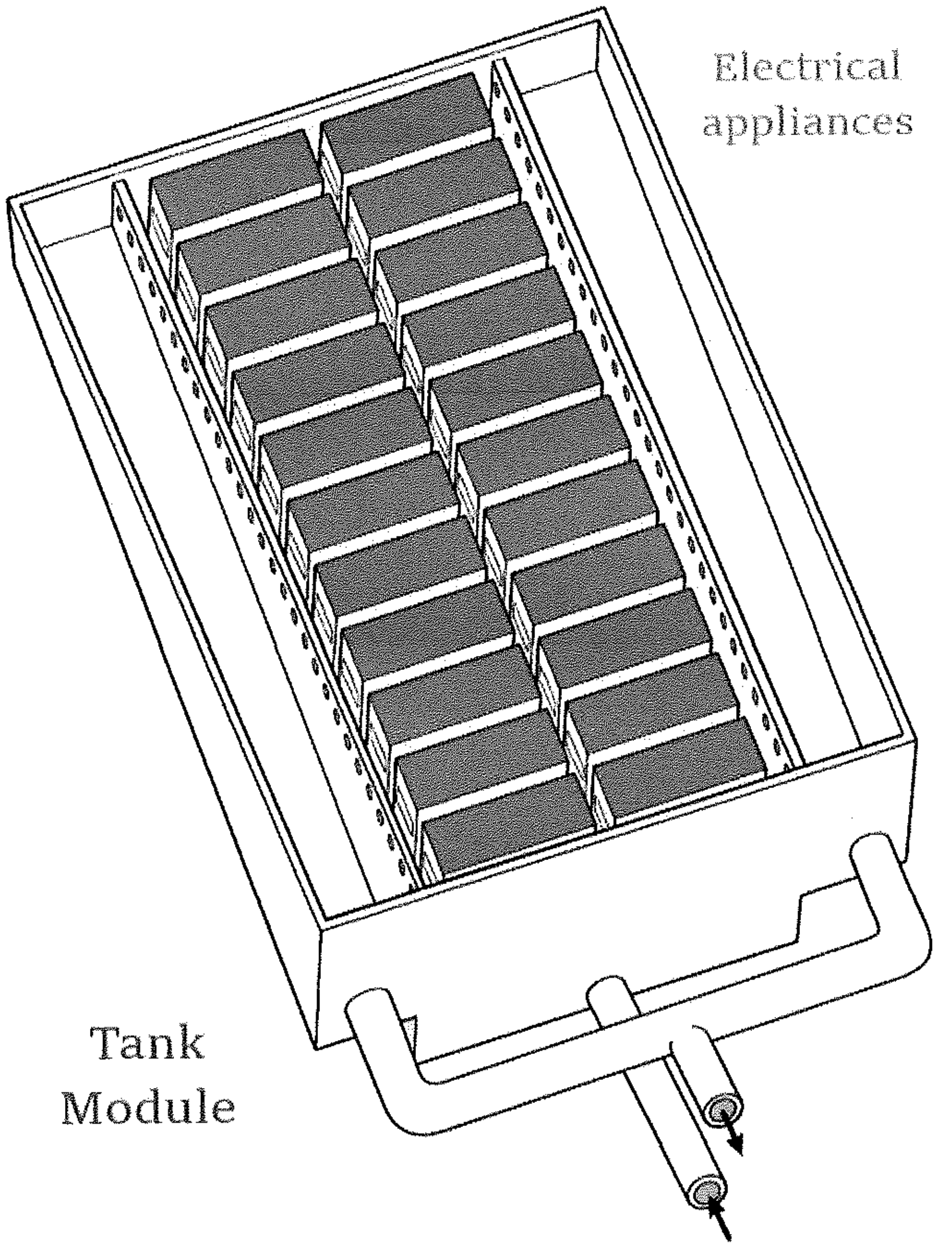
Signed and Sealed this
Fourth Day of January, 2022

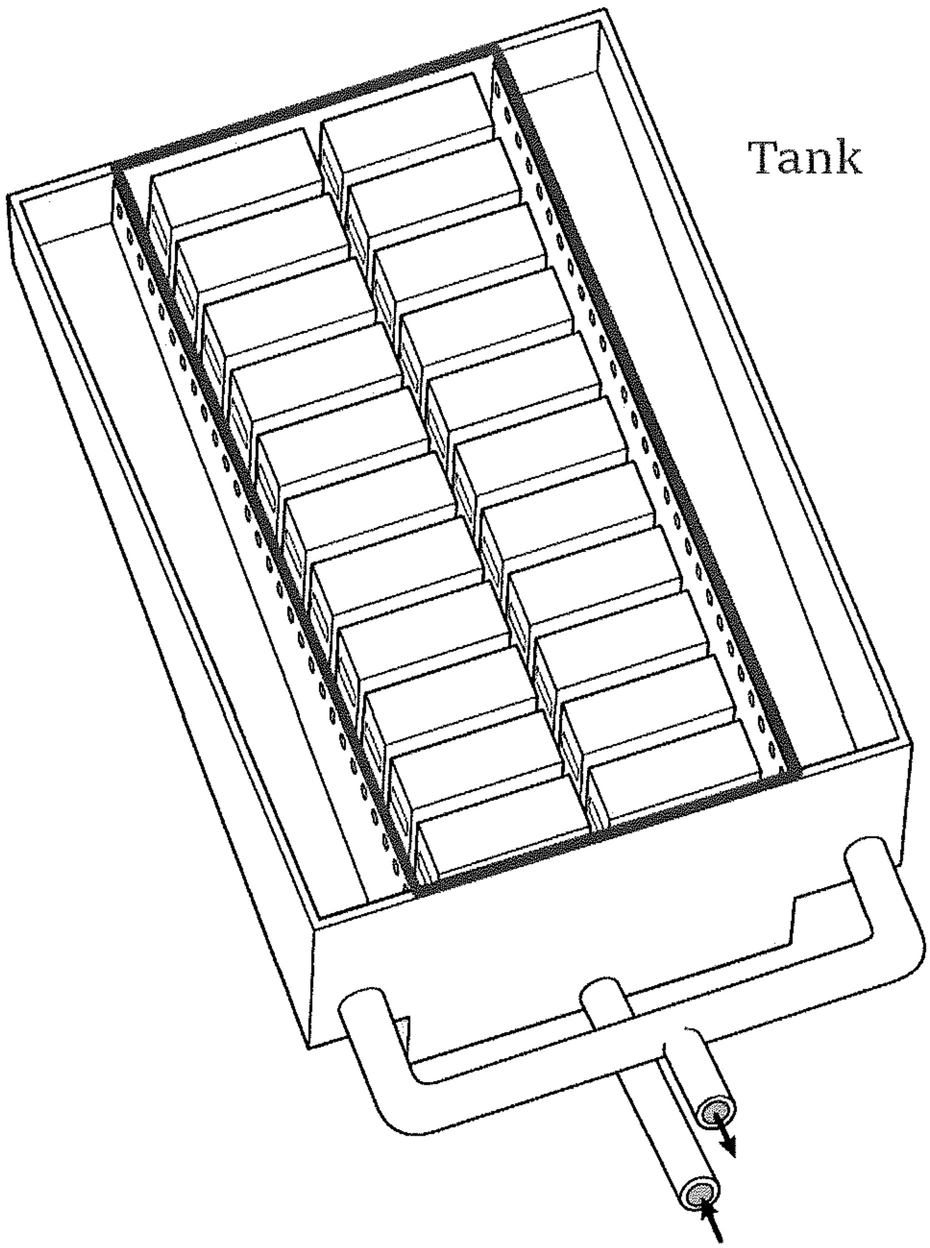
Drew Hirshfeld
Performing the Functions and Duties of the
Under Secretary of Commerce for Intellectual Property and
Director of the United States Patent and Trademark Office

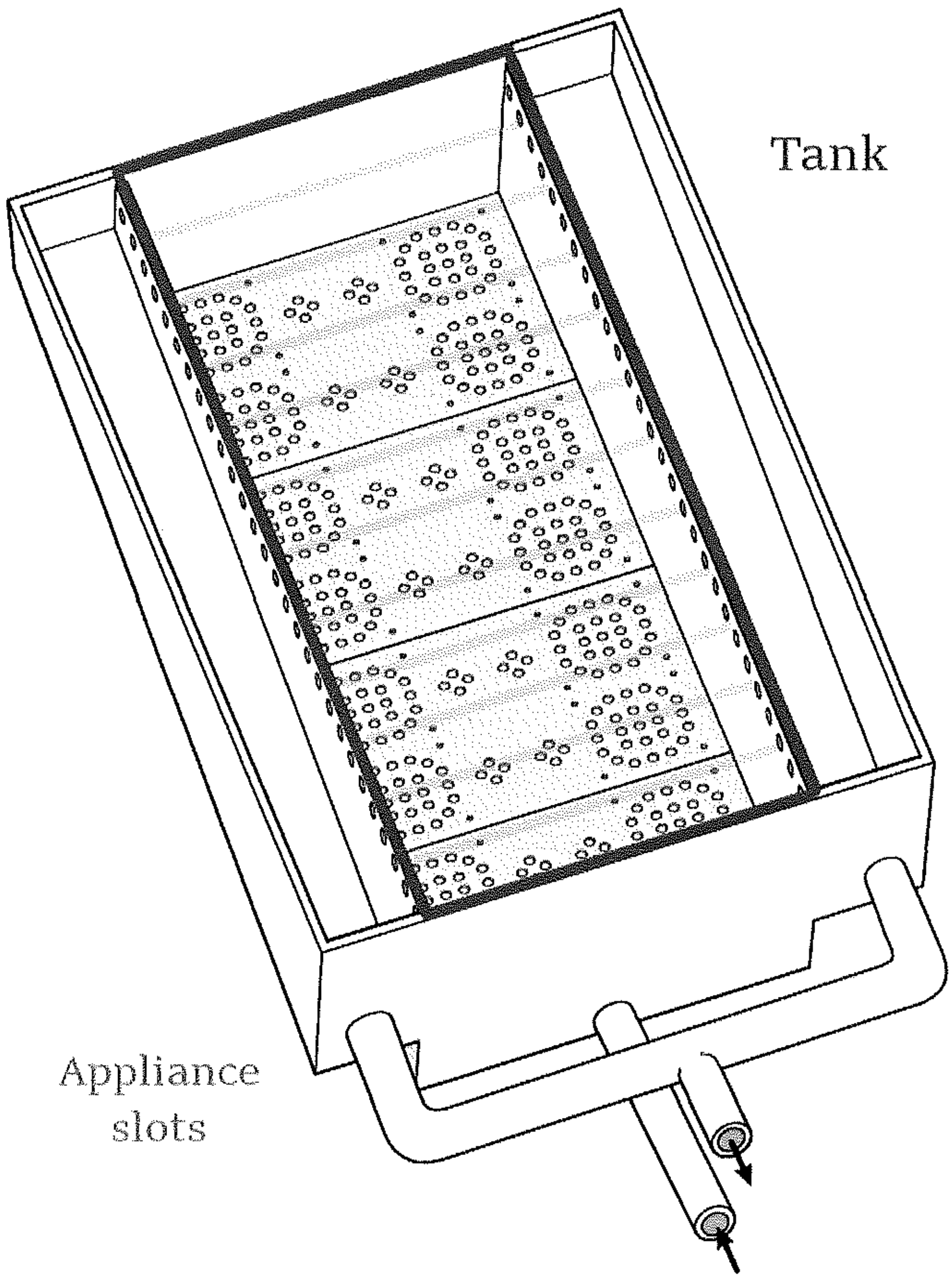
EXHIBIT C

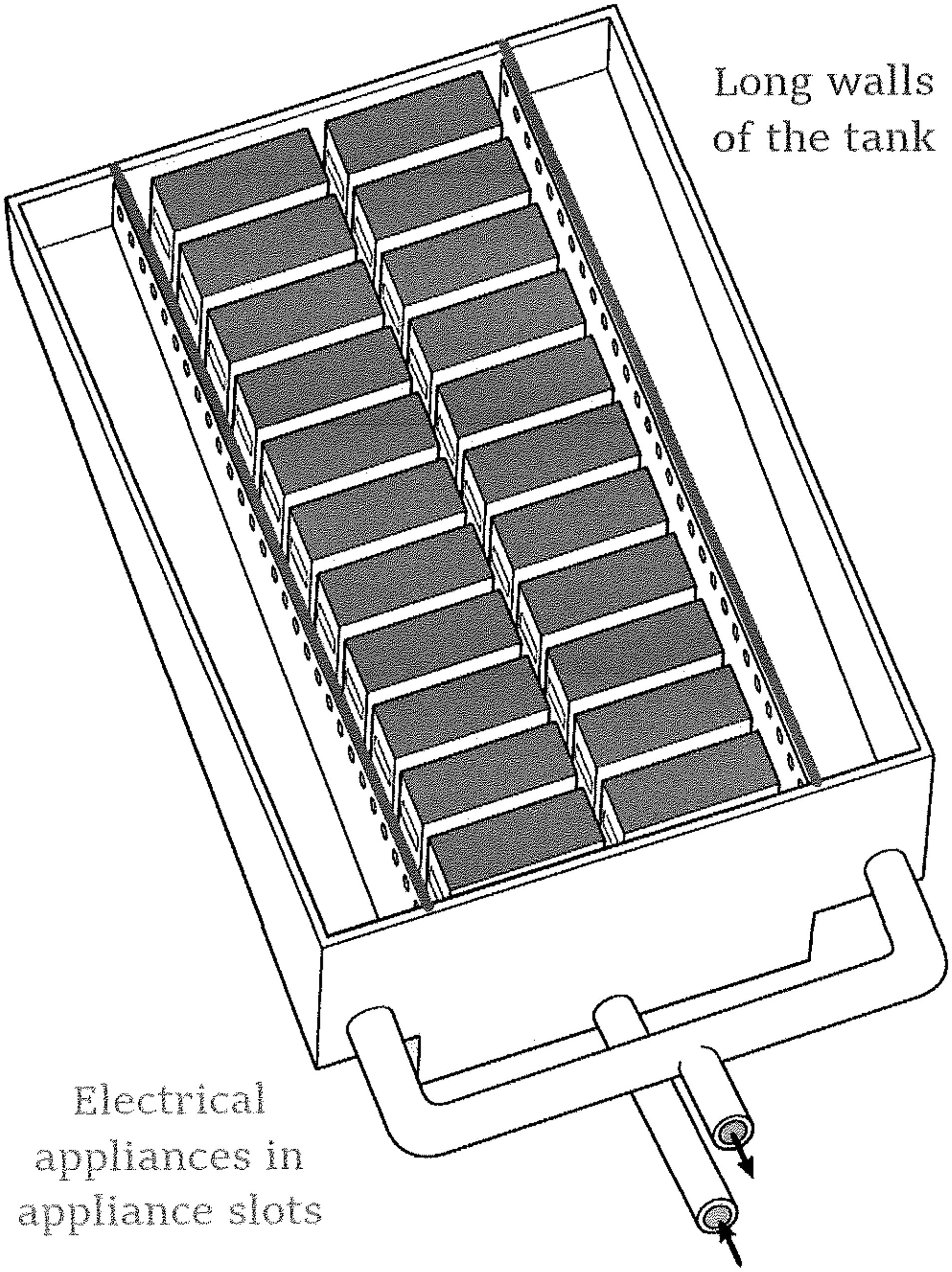
'457 Patent, Claim 6 Claim Chart

Claim Elements	Infringement by the Accused Rhodium Instrumentality
6. A tank module adapted for use in an appliance cooling system, the tank module comprising:	Accused infringers Rhodium Technologies LLC and Rhodium Enterprises, Inc. and their subsidiaries (together "Rhodium"), as well as the individual defendants, own, develop, acquire, and use tank modules adapted for use in an appliance cooling system (the Accused Instrumentality). Rhodium is "an industrial-scale digital asset technology company" that mines bitcoin with a "fully integrated infrastructure platform" that includes "directly owning and operating [its] own customized mining sites." Amendment No. 4 to Form S-1 at 1, Rhodium Enterprises, Inc. (filed Dec. 14, 2021), *available at* https://sec.report/Document/0001213900-21-065116/fs12021a4_rhodium.htm. "The cornerstone of [Rhodium's] infrastructure platform is [its] liquid-cooling technology" which is "uniquely designed" to "maintain low operating costs and manage energy consumption." *Id.* Rhodium "design[s], build[s], operat[es], and maintain[s]" tank modules adapted for use in a liquid appliance cooling system. *Id.* ("Our technology allows us to submerge our bitcoin miners in the fluid"); *see also id.* at 58 ("We own specialized computers ('miners')"); "Miners are comprised of sensitive electrical equipment"). On information and belief, the below drawing approximately depicts the tank module of Accused Instrumentality which is adapted for use in an

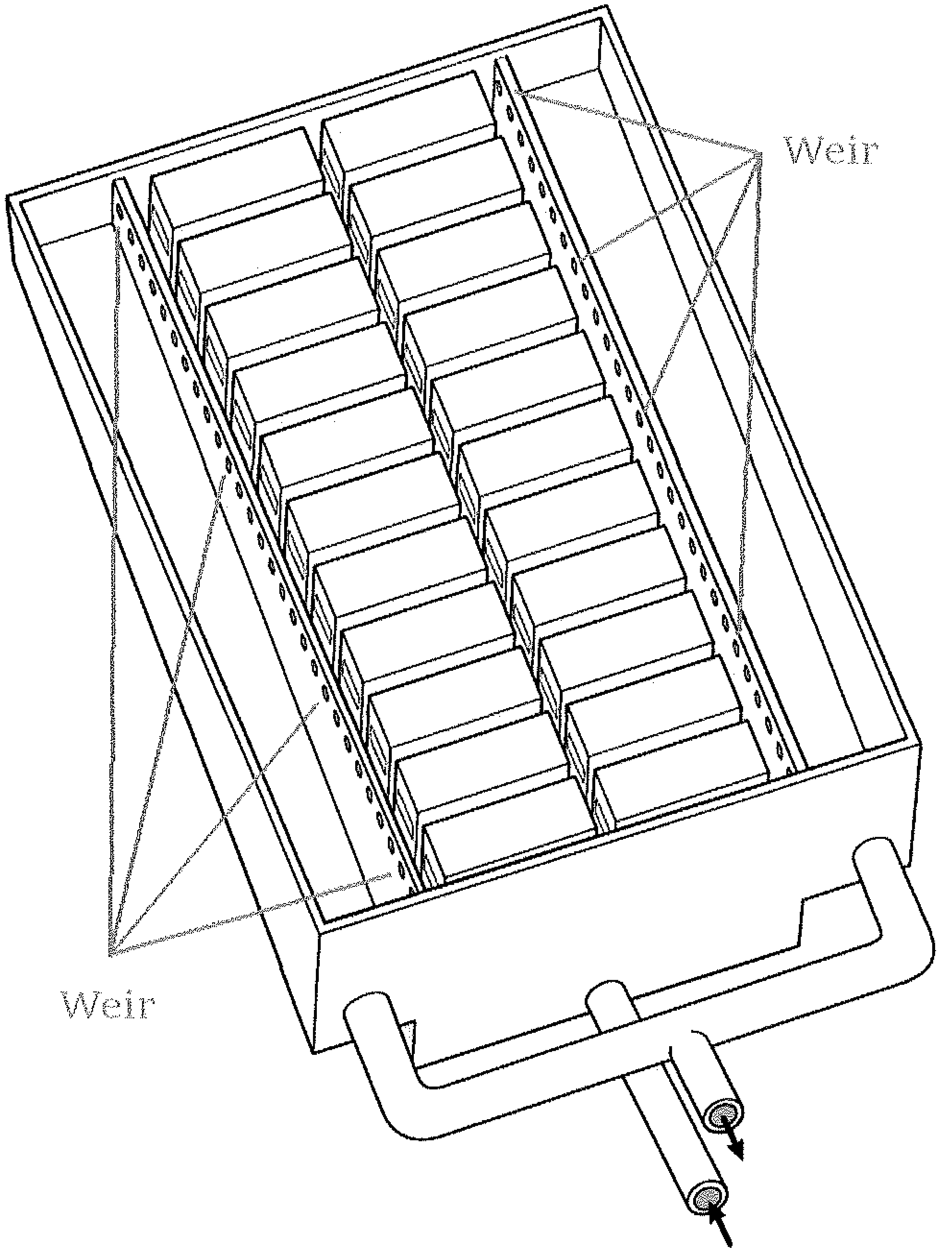
	appliance cooling system (the tank module also includes the control facility, which is not depicted below): 
a. A tank adapted to immerse in a dielectric fluid a plurality of electrical appliances,	The Accused Instrumentality includes a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank. Specifically, the tank holds dielectric fluid in which Rhodium's mining computers, i.e. electrical appliances, are submerged. *See* SEC Form 1 at 78 ("Liquid-cooling technology, on the other hand, reduces these issues

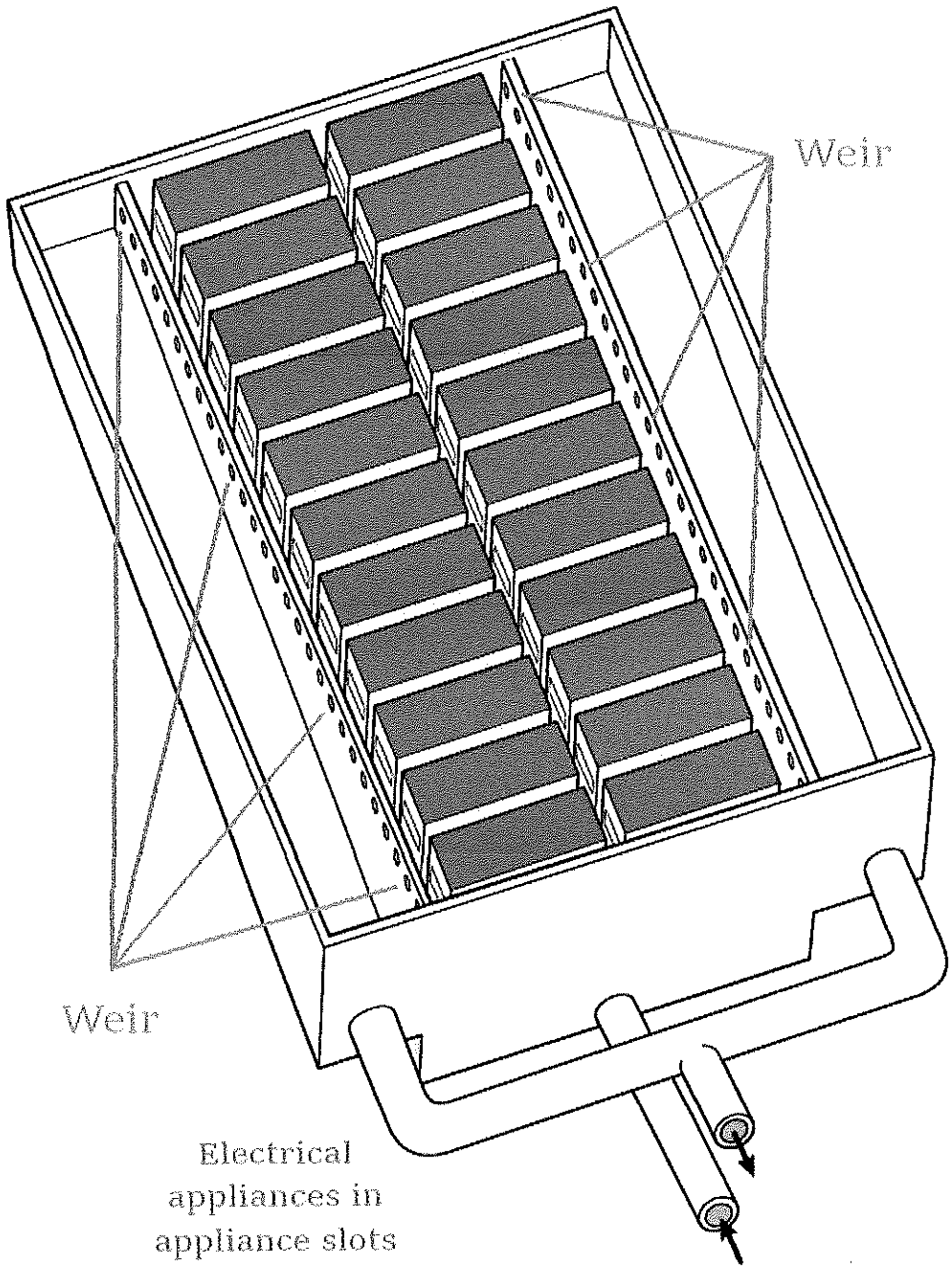
each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising:	by submerging miners in a dielectric, oil-based fluid that creates an environment more conducive to efficient heat extraction and transfer."); *id.* at 1 ("Our technology allows us to submerge our bitcoin miners in the fluid"). On information and belief, the below drawing approximately depicts a Rhodium tank (with electrical appliances installed) : 

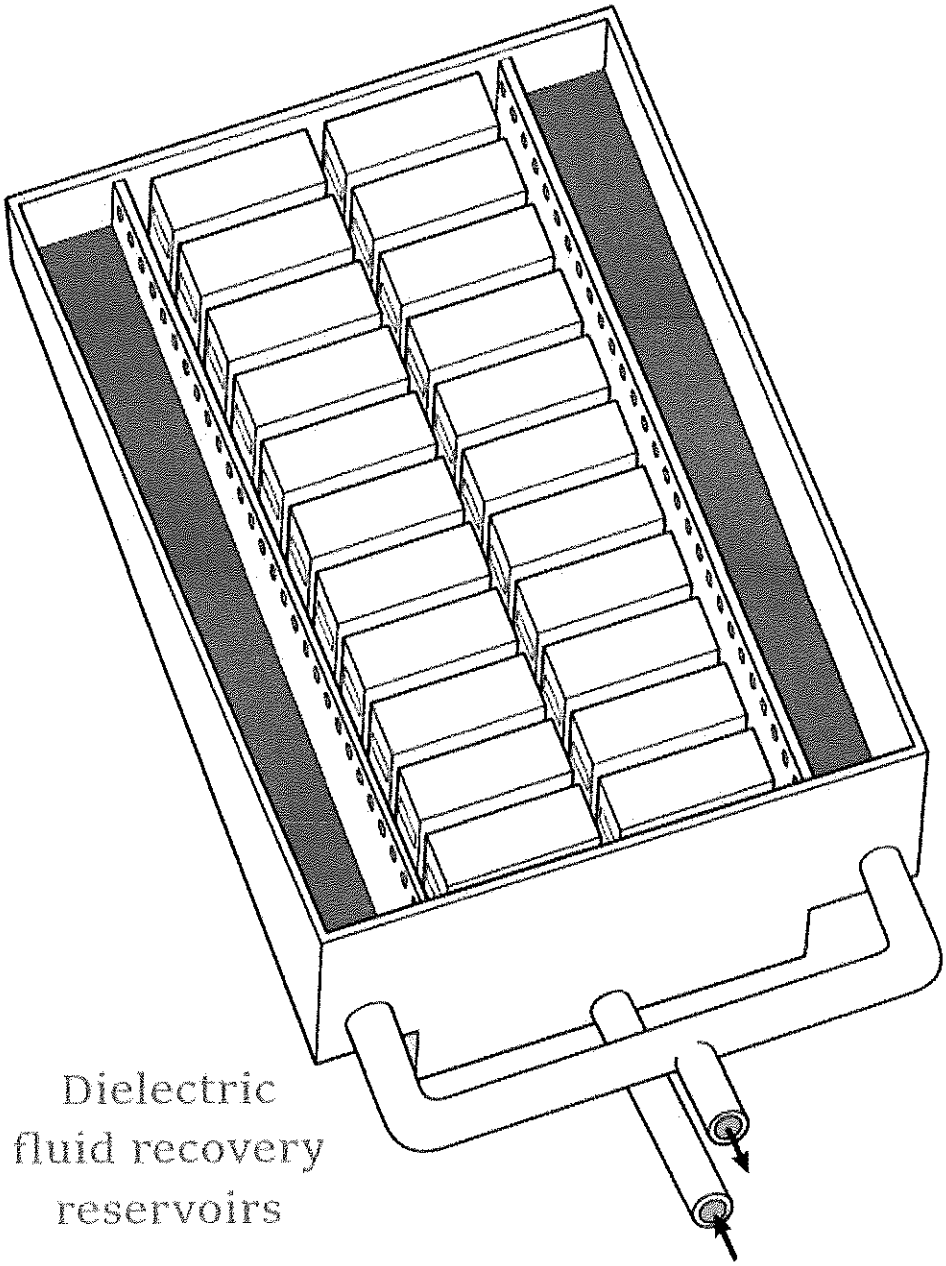
	On information and belief, the below drawing approximately depicts the tank without the installed electrical appliances:  On information and belief, in use, the tank is filled with dielectric fluid, and a plurality of electrical appliances (i.e. bitcoin mining computers, the tops of which are depicted in green) are placed in respective

	appliance slots distributed vertically along, and extending transverse to, a long wall of the tank, as shown in approximation below: 
i. A weir, integrated	The tank of Rhodium's Accused Instrumentality includes a weir,[1] integrated horizontally adjacent all appliance slots, having an overflow

[1] The Court in *Midas Green Technologies, LLC v. Immersion Systems LLC* has adopted the parties' agreed construction for the term "weir," construing it to mean "an overflow structure or barrier that determines the level of liquid". *See* Dkt. 84, at 9 (referring Dkt. 82-1, at 2.)

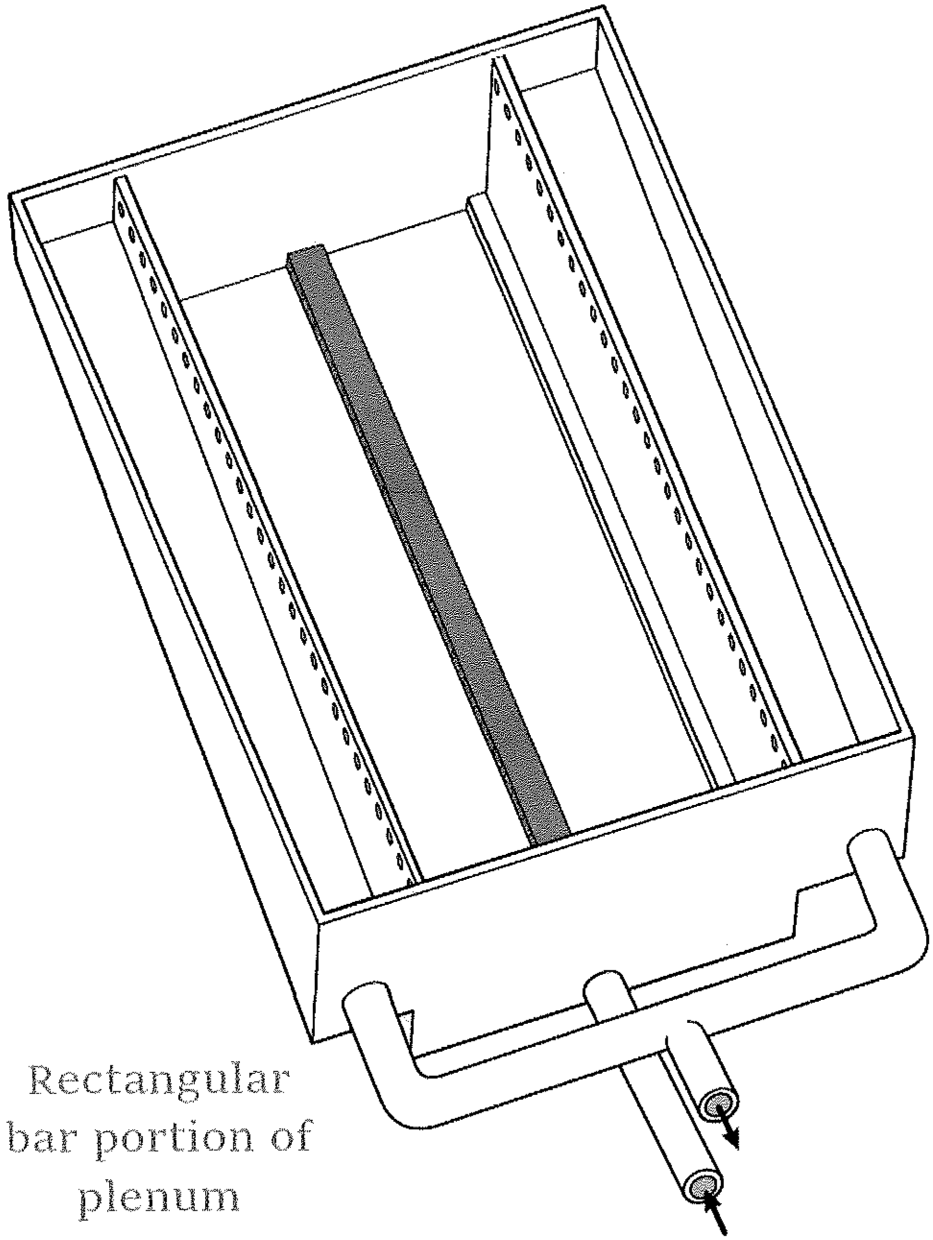
horizontally adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot; and;	lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot. Specifically, the tank includes circular holes that comprise a weir. There are weirs on both sides of the tank. On information and belief, the below drawing approximately depicts the two weirs of Rhodium's Accused Instrumentality: 

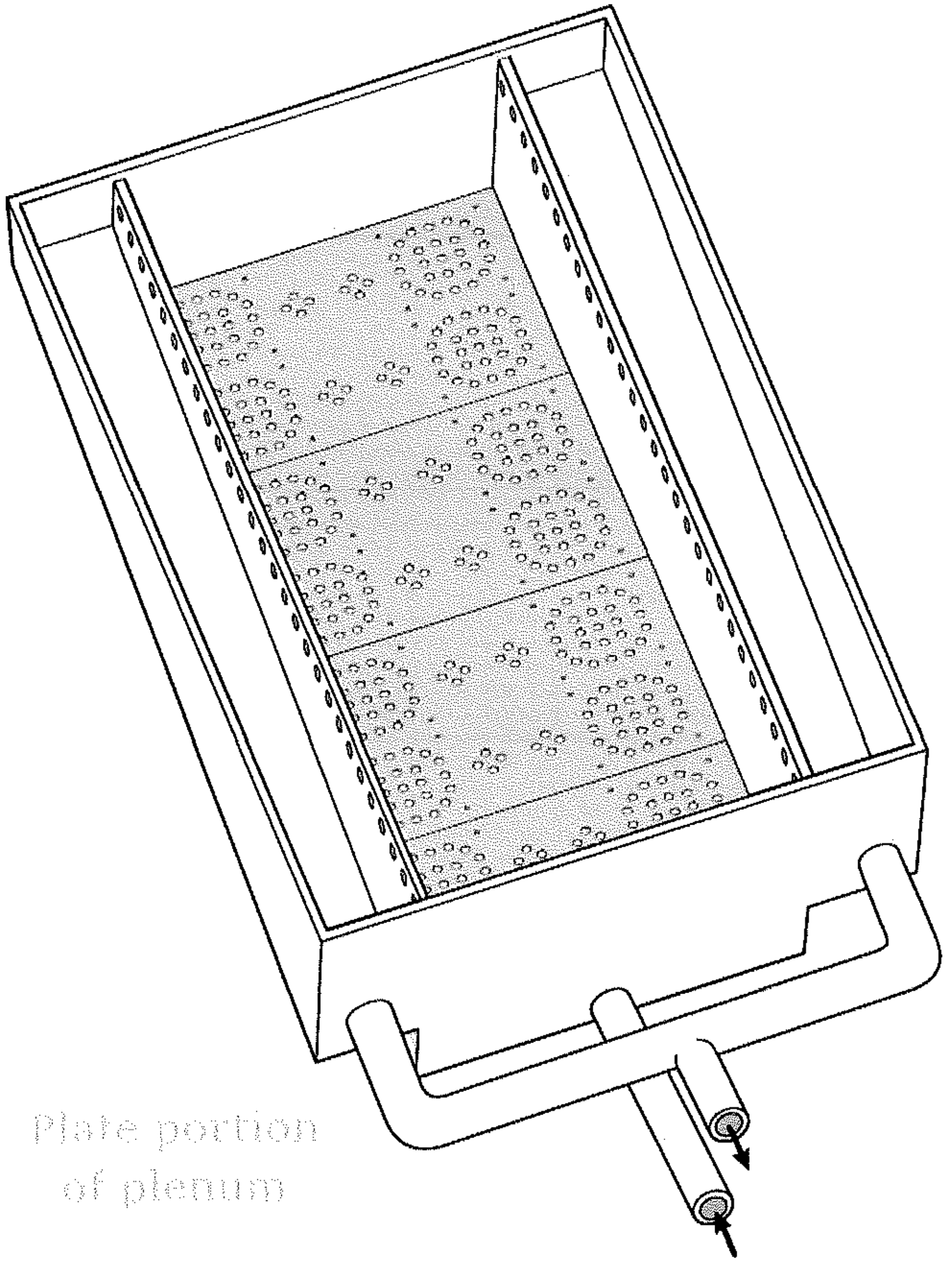
	The weir is integrated horizontally adjacent to the appliance slots and the weir is adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot. 
ii. A dielectric fluid recovery reservoir	The tank of Rhodium's Accused Instrumentality includes a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the fluid as it flows over the weir.

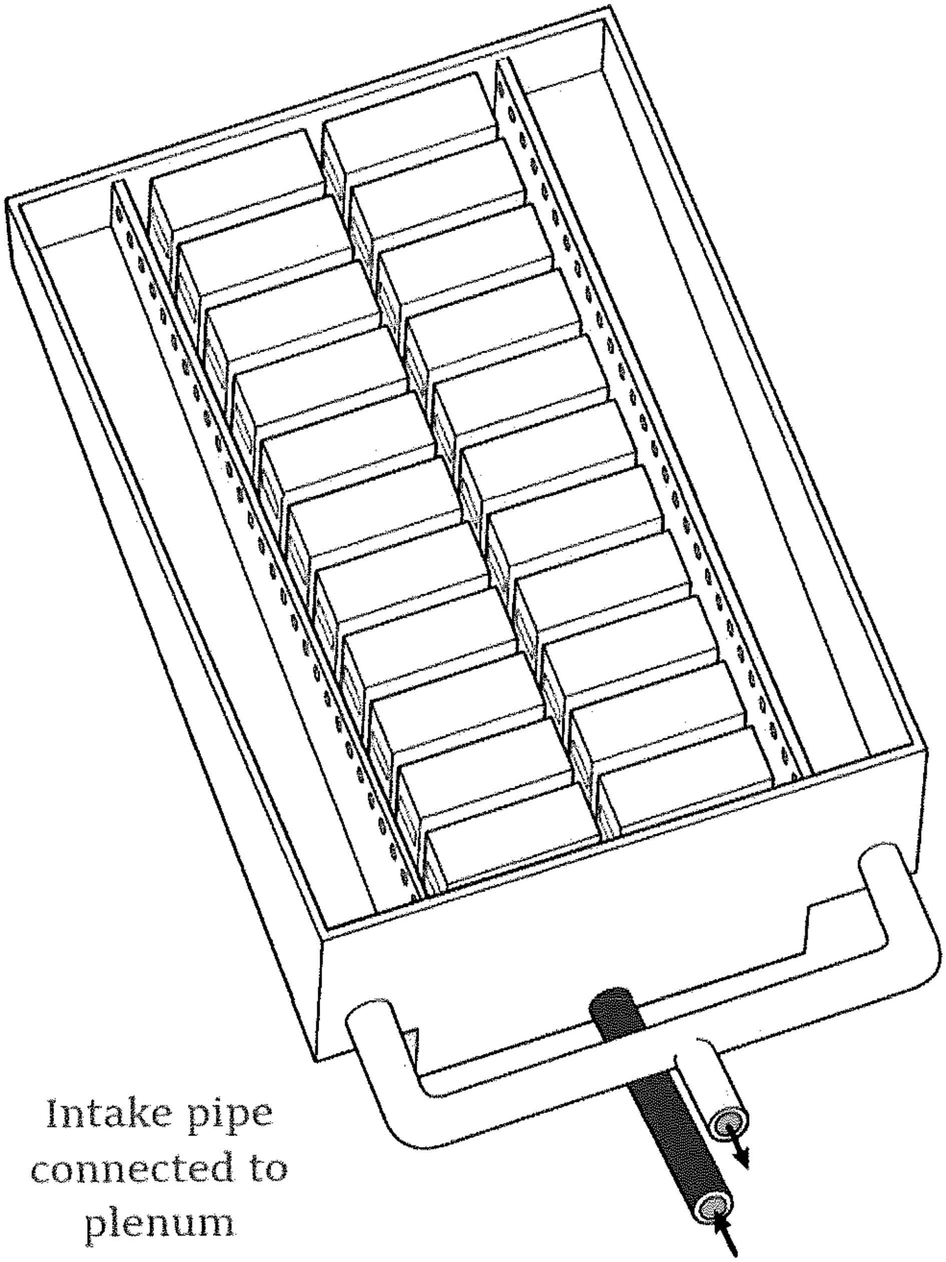
positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir;	Specifically, the Accused Instrumentality includes two dielectric fluid recovery reservoirs on either side of the tank that are positioned beneath the weirs and are adapted to receive the dielectric fluid as it flows over the circular hole weirs and down into the reservoirs. 
b. A primary circulation facility adapted to	The Rhodium Accused Instrumentality includes a primary circulation facility adapted to circulate the dielectric fluid through the tank (as detailed below).

circulate the dielectric fluid through the tank, comprising:	
i. A plenum positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot; and	The Rhodium Accused Instrumentality includes a plenum[2] positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot. Specifically, the plenum of the Rhodium Accused Instrumentality includes two components: (1) a rectangular bar or pipe that is adjacent to the bottom of the tank with circular holes in either sides that are adapted to dispense fluid substantially uniformly upwardly through each appliance slot; and (2) plates with a certain pattern of circular holes, where the plates are placed above the top of the rectangular bar or pipe and extending horizontally across the bottom of the entire tank, also adjacent to the bottom of the tank. The plates with their patterns of circular holes are adapted to dispense fluid substantially uniformly upwardly through each appliance slot. The dielectric fluid flows out of the holes of the first component then through the holes of the second component and up through each appliance slot substantially uniformly. On information and belief, the below drawings approximately depict each component of the plenum.

[2] The Court in *Midas Green Technologies, LLC v. Immersion Systems LLC* has adopted the parties' agreed construction for the term "plenum," construing it to mean "a structure for dispensing liquid". *See* Dkt. 84, at 9 (referring Dkt. 82-1, at 3.)


Rectangular
bar portion of
plenum

	 The below drawing depicts the dielectric fluid inlet pipe connected to the plenum, below the outtake pipe that is connected to the dielectric fluid recovery reservoirs:

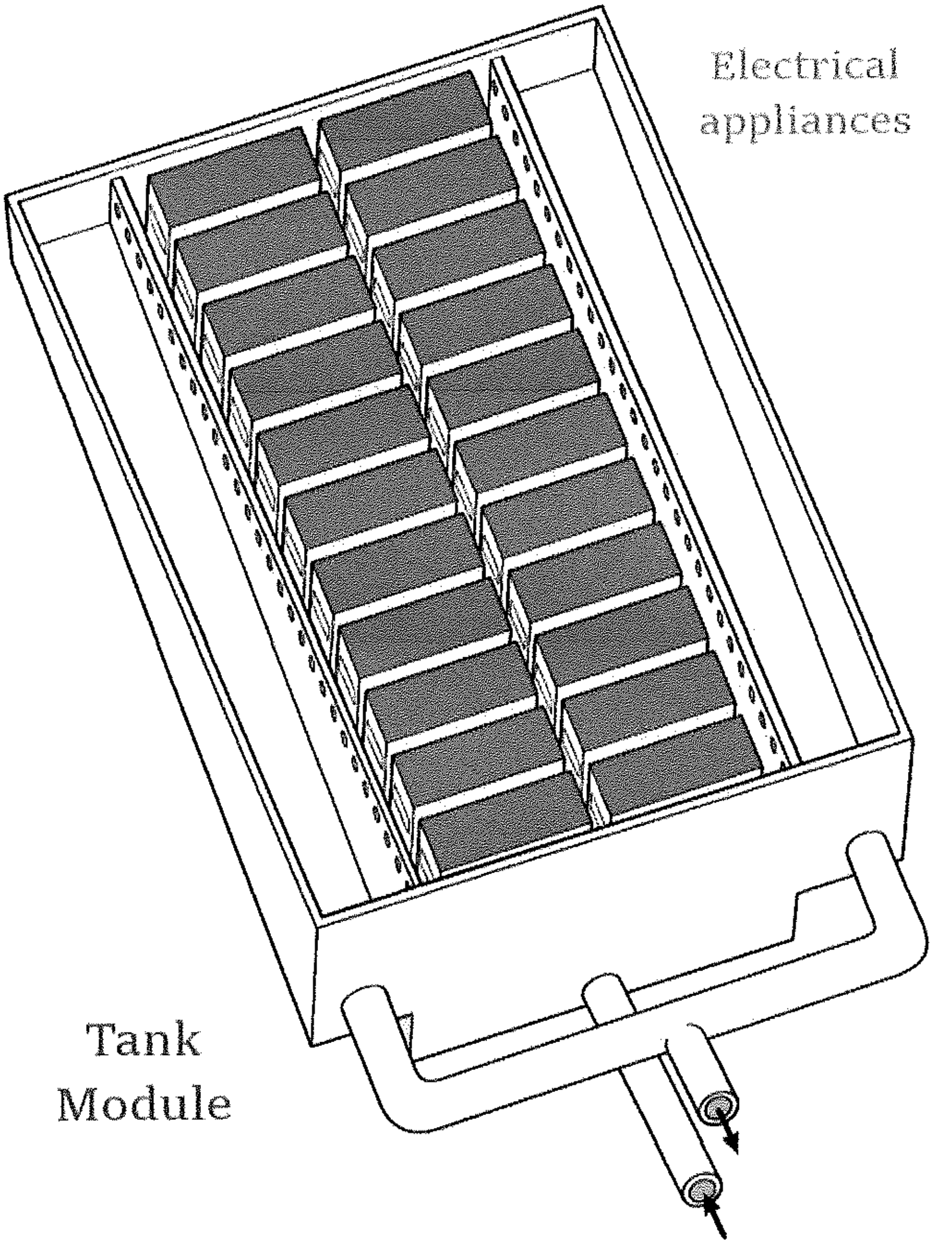
	
c. A control facility adapted to control the operation of the primary fluid circulation facility as a function of	On information and belief, in operation, the Rhodium Accused Instrumentality's tank module includes a control facility adapted to control the operation of the primary fluid circulation facility as a function of the temperature of the dielectric fluid in the tank. Specifically, the control facility includes an automated controller with software that monitors and controls the pumps, dry coolers, and temperature of the dielectric fluid in the tanks through the use of sensors. *See, e.g.*, Amendment No. 4 to Form S-1 at 74, Rhodium Enterprises, Inc. (filed Dec. 14, 2021), *available at*

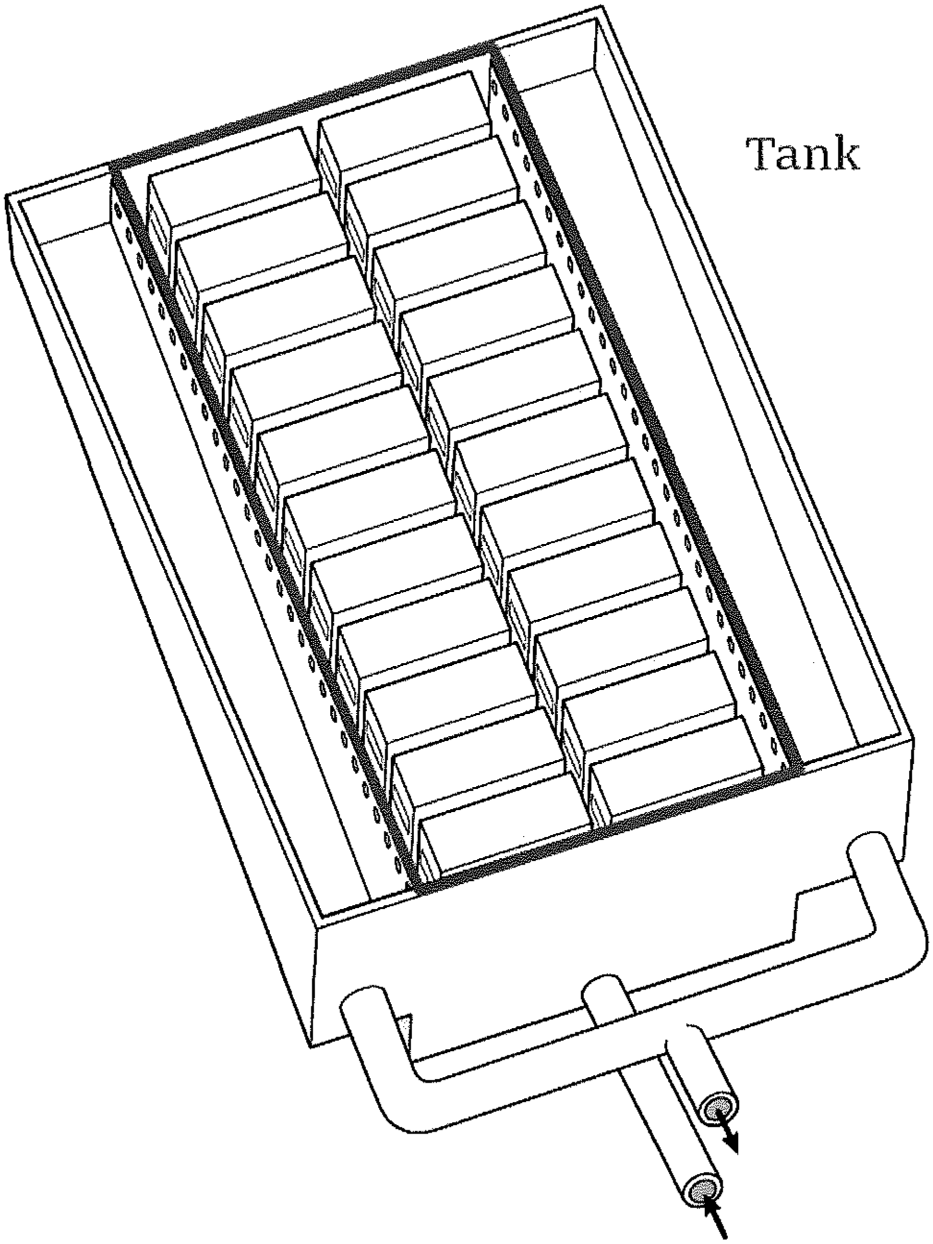
the temperature of the dielectric fluid in the tank.	https://sec.report/Document/0001213900-21-065116/fs12021a4_rhodium.htm ("Additionally, we have developed and maintained proprietary software to optimize performance of our miners and infrastructure in real-time . . . . Specifically, our software allows us to make quicker, and data-informed, decisions, securely and rapidly put miners online and more effectively manage temperature and energy."); *id.* at 79 ("In tandem to developing our own software, we employ sensors not only telling us the temperature of each miner in real-time through visual heat maps, but we have also installed microsensors throughout our liquid-cooling plumbing system that measure flow rate, temperature and presume. Using machine learning technology and the data points collected by these sensors, robotic process automation (RPA) triggers a tuning response to the power intake as needed to either remediate or optimize miner performance.").

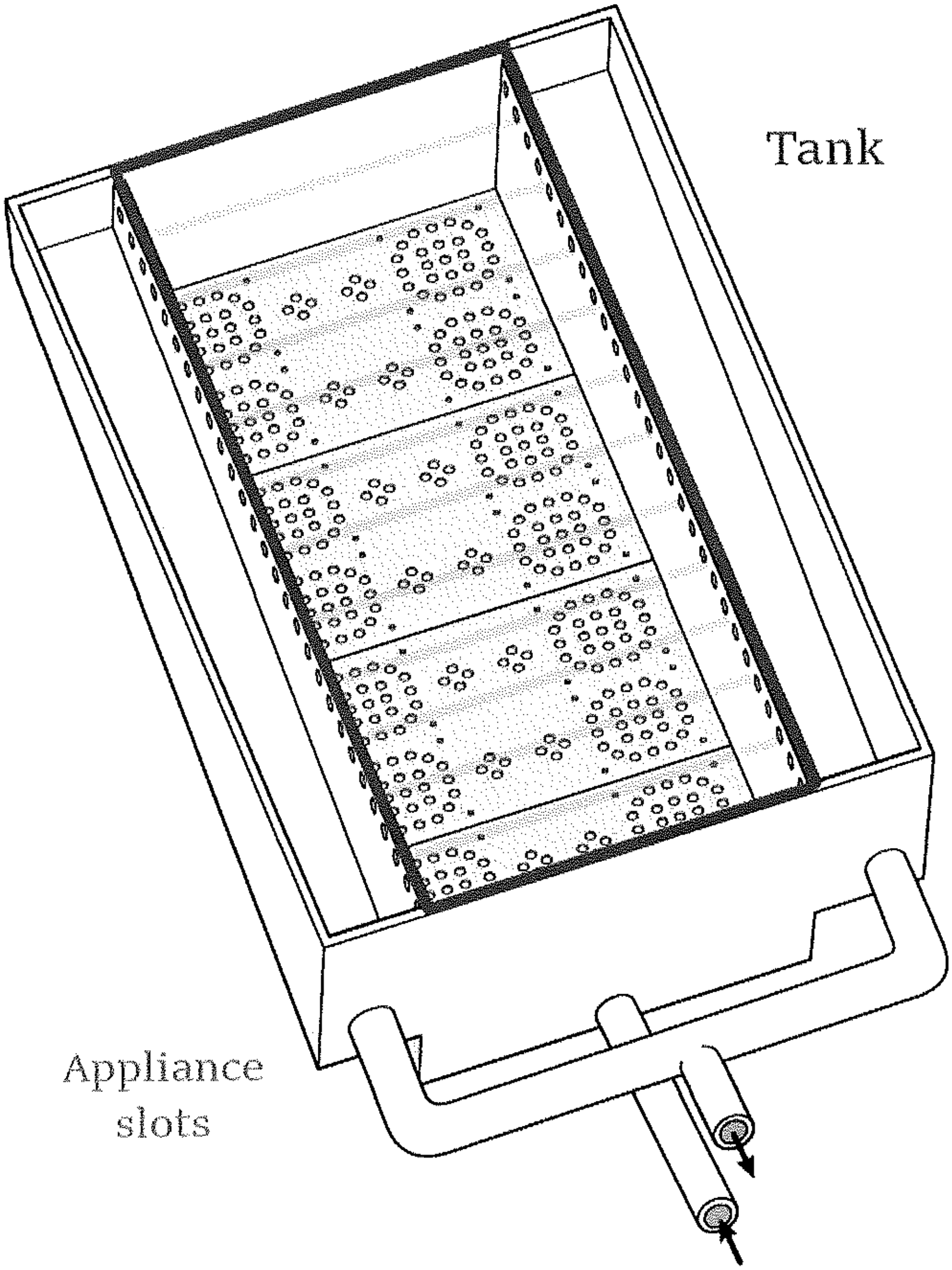
EXHIBIT D

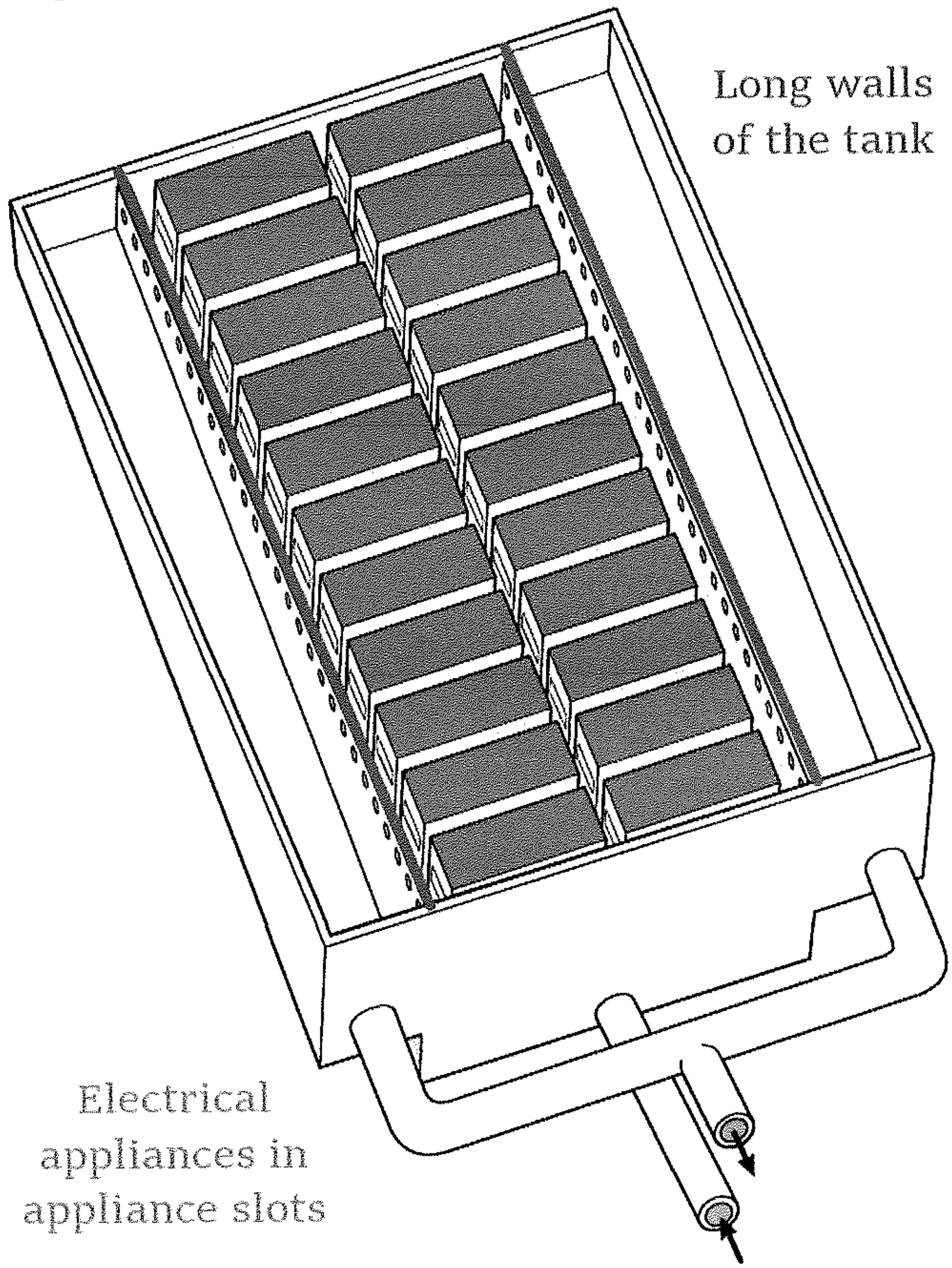
'446 Patent, Claim 6 Claim Chart

Claim Elements	Infringement by the Accused Rhodium Instrumentality
6. A tank module adapted for use in an appliance cooling system, the tank module comprising:	Accused infringers Rhodium Technologies LLC and Rhodium Enterprises, Inc. and their subsidiaries (together "Rhodium"), as well as the individual defendants, own, develop, acquire, and use tank modules adapted for use in an appliance cooling system (the Accused Instrumentality). Rhodium is "an industrial-scale digital asset technology company" that mines bitcoin with a "fully integrated infrastructure platform" that includes "directly owning and operating [its] own customized mining sites." Amendment No. 4 to Form S-1 at 1, Rhodium Enterprises, Inc. (filed Dec. 14, 2021), *available at* https://sec.report/Document/0001213900-21-065116/fs12021a4_rhodium.htm. "The cornerstone of [Rhodium's] infrastructure platform is [its] liquid-cooling technology" which is "uniquely designed" to "maintain low operating costs and manage energy consumption." *Id.* Rhodium "design[s], build[s], operat[es], and maintain[s]" tank modules adapted for use in a liquid appliance cooling system. *Id.* ("Our technology allows us to submerge our bitcoin miners in the fluid"); *see also id.* at 58 ("We own specialized computers ('miners')"); "Miners are comprised of sensitive electrical equipment"). On information and belief, the below drawing approximately depicts the tank module of Accused Instrumentality which is adapted for use in an

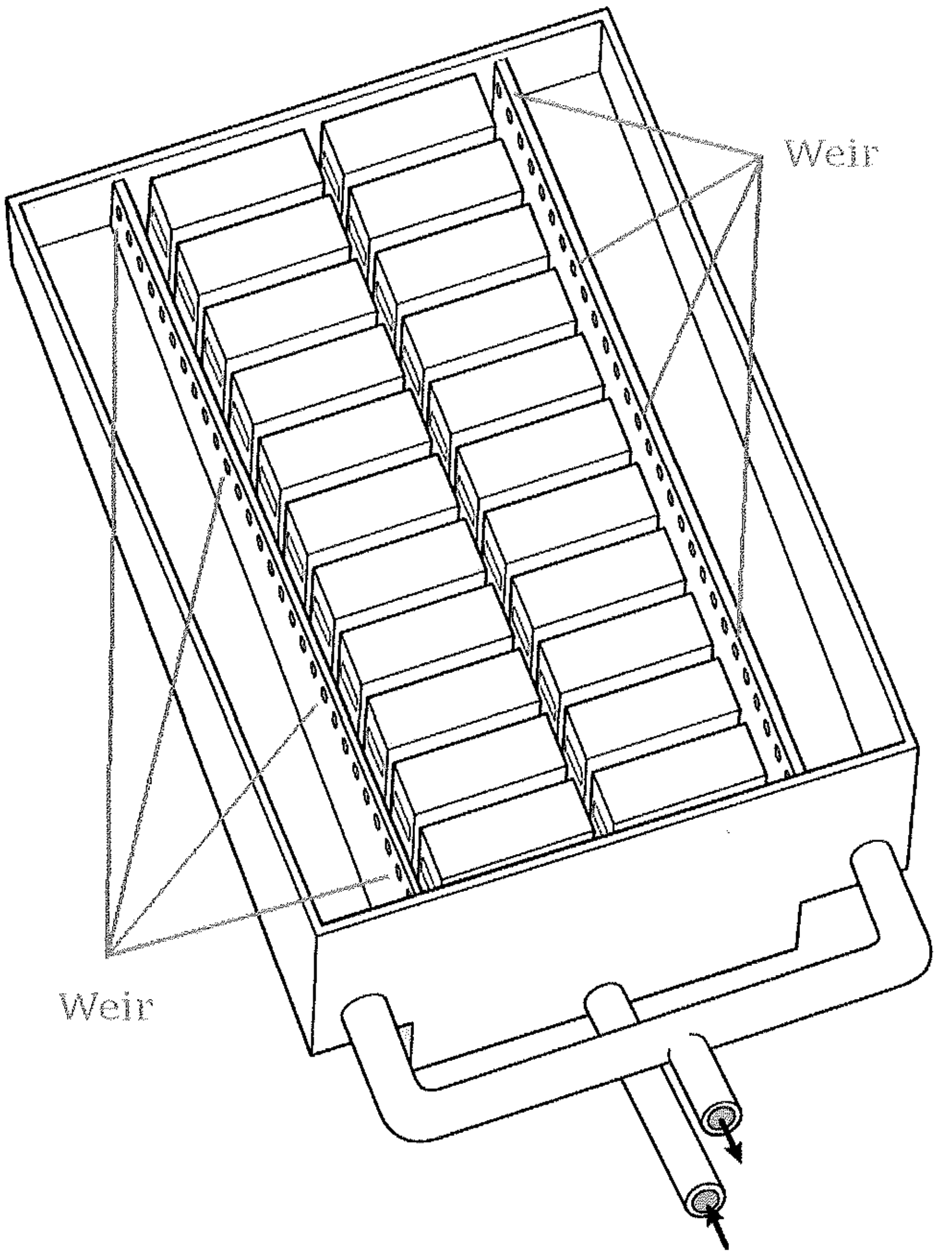
	appliance cooling system (the tank module also includes the control facility, which is not depicted below): 
a. A tank adapted to immerse in a dielectric fluid a plurality of electrical appliances,	The Accused Instrumentality includes a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank. Specifically, the tank holds dielectric fluid in which Rhodium's mining computers, i.e. electrical appliances, are submerged. *See* SEC Form 1 at 78 ("Liquid-cooling technology, on the other hand, reduces these issues

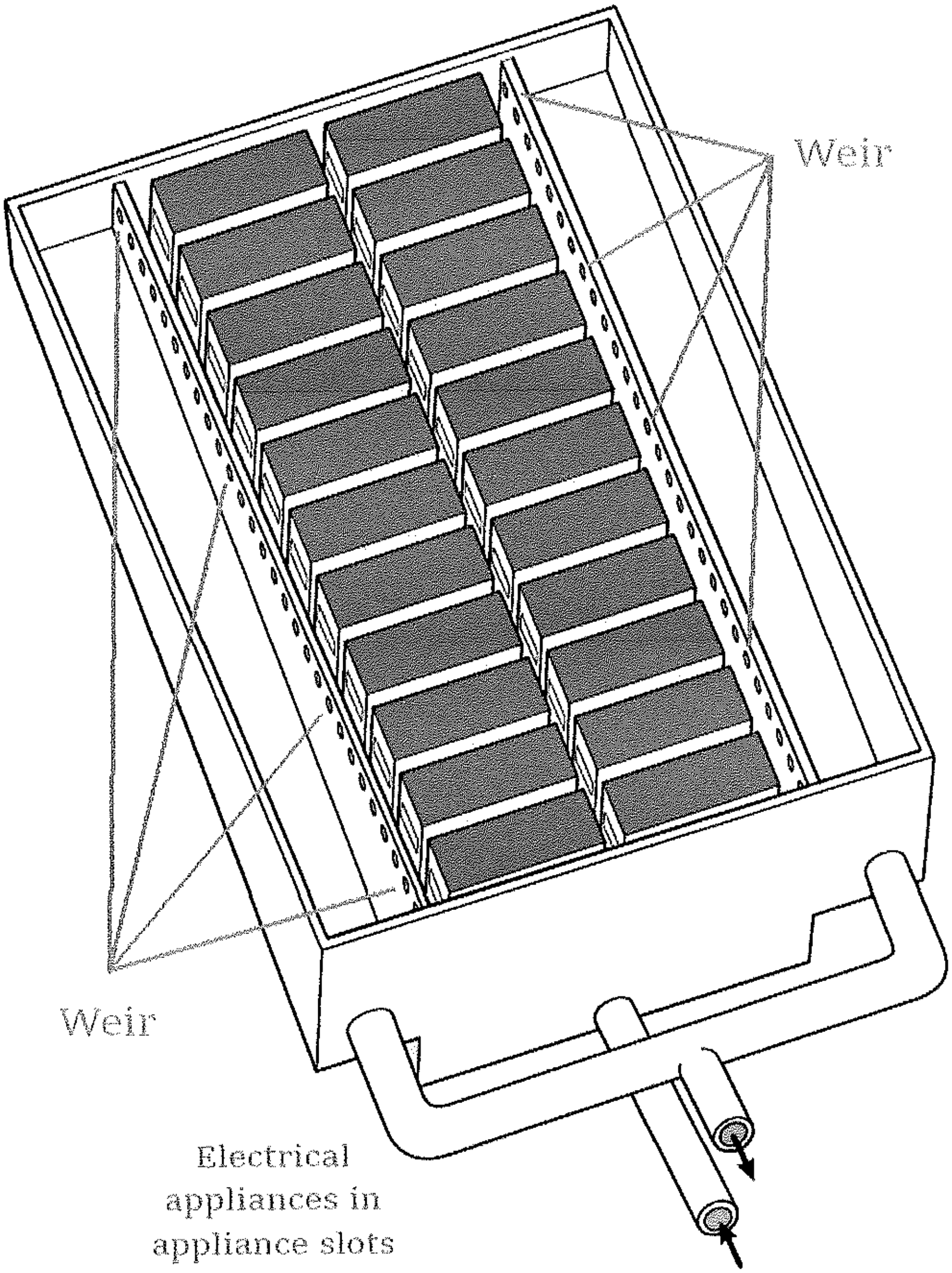
each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising:	by submerging miners in a dielectric, oil-based fluid that creates an environment more conducive to efficient heat extraction and transfer."); *id.* at 1 ("Our technology allows us to submerge our bitcoin miners in the fluid"). On information and belief, the below drawing approximately depicts a Rhodium tank (with electrical appliances installed) : 

	On information and belief, the below drawing approximately depicts the tank without the installed electrical appliances:  On information and belief, in use, the tank is filled with dielectric fluid, and a plurality of electrical appliances (i.e. bitcoin mining computers, the tops of which are depicted in green) are placed in respective

	appliance slots distributed vertically along, and extending transverse to, a long wall of the tank, as shown in approximation below: 
i. A weir, integrated	The tank of Rhodium's Accused Instrumentality includes a weir,[1] integrated horizontally into the long wall of the tank adjacent all

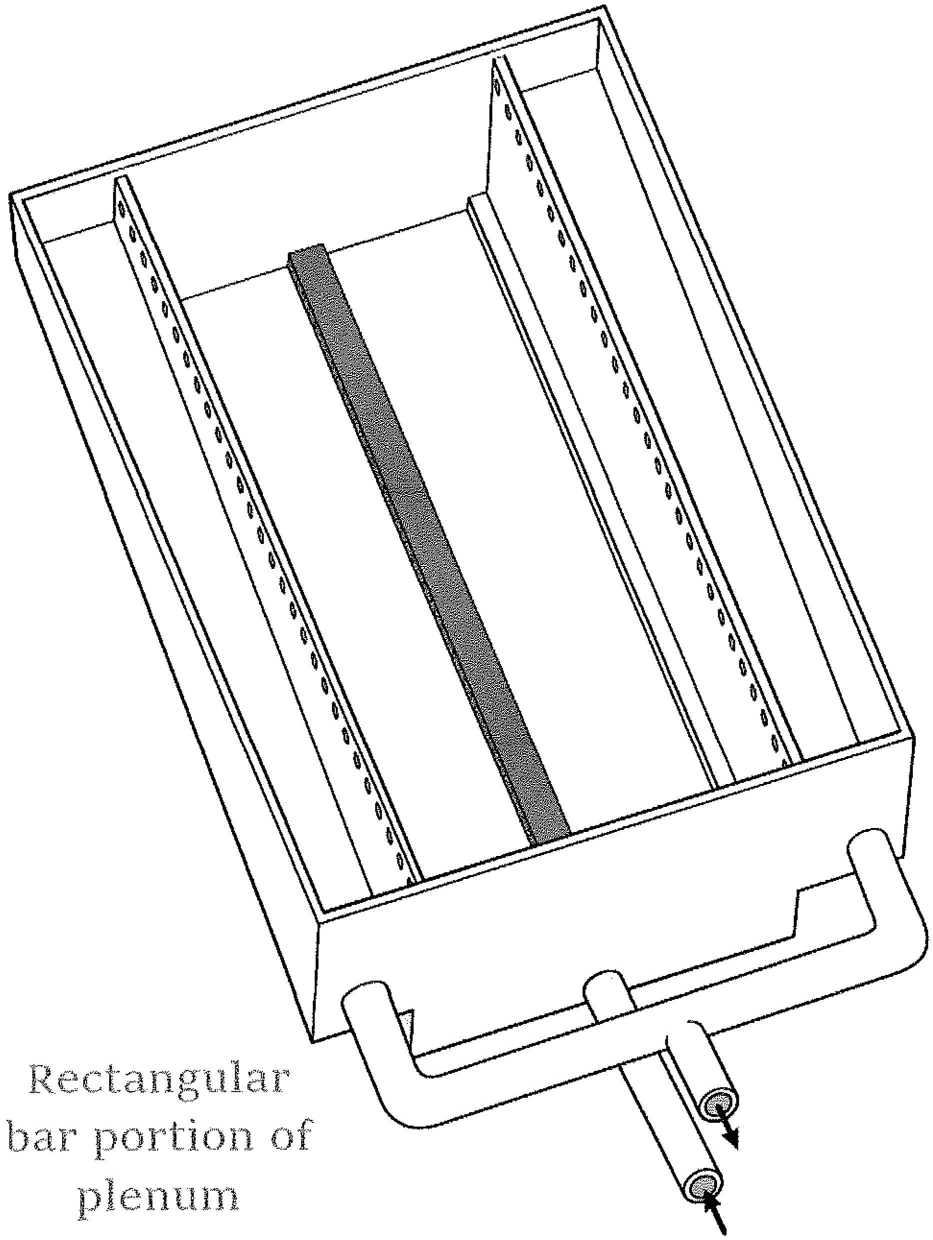
[1] The Court in *Midas Green Technologies, LLC v. Immersion Systems LLC* has adopted the parties' agreed construction for the term "weir," construing it to mean "an overflow structure or barrier that determines the level of liquid". *See* Dkt. 84, at 9 (referring Dkt. 82-1, at 2.)

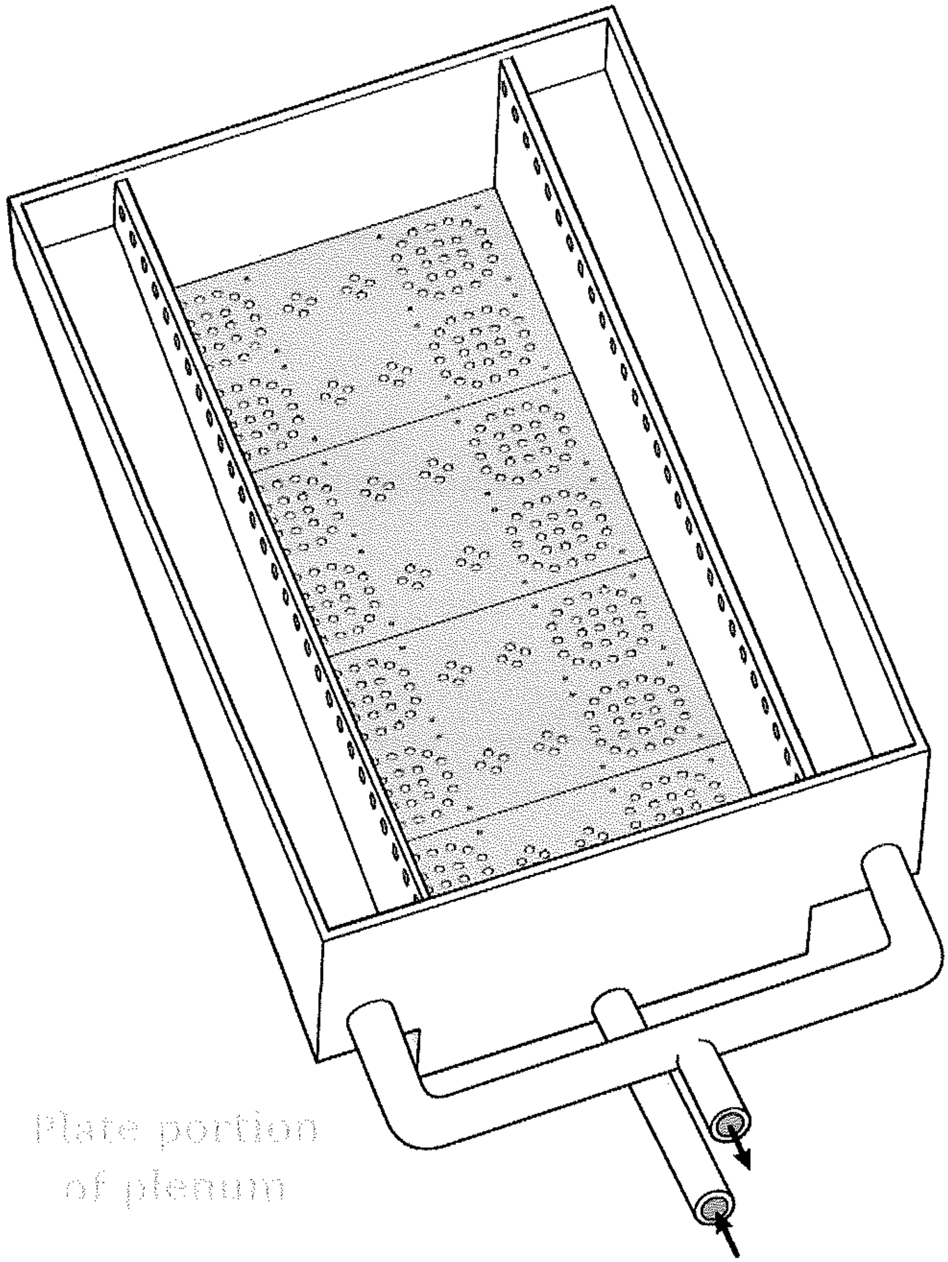
horizontally into the long wall of the tank adjacent all appliance slots, adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot; and;	appliance slots, adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot. Specifically, the tank includes circular holes that comprise a weir. There are weirs on both sides of the tank. On information and belief, the below drawing approximately depicts the two weirs of Rhodium's Accused Instrumentality:  The weir is integrated horizontally into the long wall of the tank adjacent to the appliance slots and the weir is adapted to facilitate substantially

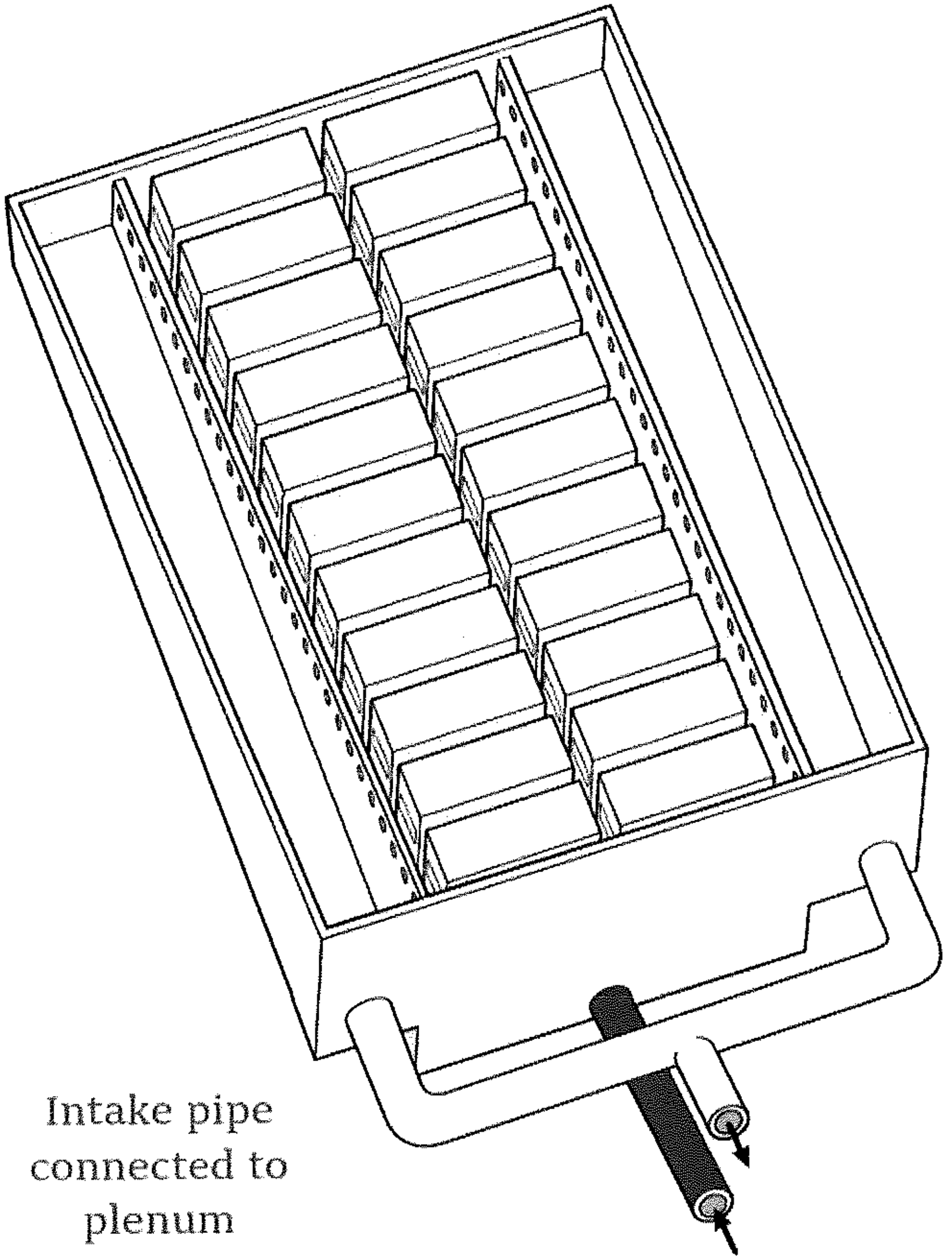
	uniform recovery of the dielectric fluid flowing through each appliance slot. 
b. A primary circulation facility adapted to circulate the dielectric	The Rhodium Accused Instrumentality includes a primary circulation facility adapted to circulate the dielectric fluid through the tank (as detailed below).

fluid through the tank, comprising:	
i. A plenum positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot; and	The Rhodium Accused Instrumentality includes a plenum[2] positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot. Specifically, the plenum of the Rhodium Accused Instrumentality includes two components: (1) a rectangular bar or pipe that is adjacent to the bottom of the tank with circular holes in either sides that are adapted to dispense fluid substantially uniformly upwardly through each appliance slot; and (2) plates with a certain pattern of circular holes, where the plates are placed above the top of the rectangular bar or pipe and extending horizontally across the bottom of the entire tank, also adjacent to the bottom of the tank. The plates with their patterns of circular holes are adapted to dispense fluid substantially uniformly upwardly through each appliance slot. The dielectric fluid flows out of the holes of the first component then through the holes of the second component and up through each appliance slot substantially uniformly. On information and belief, the below drawings approximately depict each component of the plenum.

[2] The Court in *Midas Green Technologies, LLC v. Immersion Systems LLC* has adopted the parties' agreed construction for the term "plenum," construing it to mean "a structure for dispensing liquid". *See* Dkt. 84, at 9 (referring Dkt. 82-1, at 3.)

	 Rectangular bar portion of plenum

	 The below drawing depicts the dielectric fluid inlet pipe connected to the plenum, below the outtake pipe that is connected to the dielectric fluid recovery reservoirs:

	
c. A control facility adapted to control the operation of the primary fluid circulation facility as a function of	On information and belief, in operation, the Rhodium Accused Instrumentality's tank module includes a control facility adapted to control the operation of the primary fluid circulation facility as a function of the temperature of the dielectric fluid in the tank. Specifically, the control facility includes an automated controller with software that monitors and controls the pumps, dry coolers, and temperature of the dielectric fluid in the tanks through the use of sensors. *See, e.g.*, Amendment No. 4 to Form S-1 at 74, Rhodium Enterprises, Inc. (filed Dec. 14, 2021), *available at*

the temperature of the dielectric fluid in the tank.	https://sec.report/Document/0001213900-21-065116/fs12021a4_rhodium.htm ("Additionally, we have developed and maintained proprietary software to optimize performance of our miners and infrastructure in real-time . . . . Specifically, our software allows us to make quicker, and data-informed, decisions, securely and rapidly put miners online and more effectively manage temperature and energy."); *id.* at 79 ("In tandem to developing our own software, we employ sensors not only telling us the temperature of each miner in real-time through visual heat maps, but we have also installed microsensors throughout our liquid-cooling plumbing system that measure flow rate, temperature and presume. Using machine learning technology and the data points collected by these sensors, robotic process automation (RPA) triggers a tuning response to the power intake as needed to either remediate or optimize miner performance.").

EXHIBIT E

**IN THE UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF TEXAS
FORT WORTH DIVISION**

MIDAS GREEN TECHNOLOGIES, LLC, PLAINTIFF,	§ § §	CASE NO. 4:20-cv-00555-O
V.	§ § §	JURY TRIAL DEMANDED
IMMERSION SYSTEMS LLC, DEFENDANT.	§ § § §	PATENT CASE

JOINT CLAIM CONSTRUCTION CHART

Pursuant to Rule 4-5(d) of the Second Amended Miscellaneous Order No. 62 of the Northern District of Texas, Dallas Division and the Joint Scheduling Order entered by the Court (Dkt. No. 64), Plaintiff and Counterclaim Defendant Midas Green Technologies, LLC and Defendant and Counterclaim Plaintiff Immersion Systems LLC hereby submit their Joint Claim Construction Chart, attached as Exhibit A.

Dated: October 15, 2021

Respectfully Submitted,

/s/ Artie Pennington

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COUNSEL FOR DEFENDANT
IMMERSION SYSTEMS LLC

CERTIFICATE OF SERVICE

I hereby certify that on 15th day of October, 2021, I electronically submitted the foregoing document with the clerk of court for the U.S. District Court, Northern District of Texas, using the CM/ECF filing system of the court for electronic service on all parties.

Respectfully submitted,

By: /s/ Artie Pennington
Artie Pennington

EXHIBIT A

JOINT CLAIM CONSTRUCTION CHART

Midas Green Technologies, LLC v. Immersion Systems LLC

U.S. Patent No. 10,405,457 (the " '457 Patent")
U.S. Patent No. 10,820,446 (the " '446 Patent")

I. Agreed Claim Terms.

The parties have already agreed upon the following constructions of the nineteen (19) claims.

	Patent and Claim Number(s)	Claim Term	Plaintiff's Proposed Construction	Defendant's Proposed Construction	Judge's Construction
1.	'457 Patent Claims 1, 5, 6, 10, 11, 14; '446 Patent Claims 1, 5, 6, 10	"a tank adapted to immerse"	[AGREED]	[AGREED]	Plain and Ordinary Meaning
2.	'457 Patent Claims 1, 5, 6, 10, 11, 14; '446 Patent Claims 1, 5, 6, 10	"each in a respective appliance slot"	[AGREED]	[AGREED]	Plain and Ordinary Meaning
3.	'457 Patent Claims 1, 5, 6, 10, 11, 14; '446 Patent Claims 1, 5, 6, 10	"weir"	[AGREED]	[AGREED]	"an overflow structure or barrier that determines the level of liquid"
4.	'457 Patent Claims 1, 5, 6, 10, 11, 14; '446 Patent Claims 1, 5, 6, 10	"weir, integrated horizontally into the long wall"	[AGREED]	[AGREED]	Plain and Ordinary Meaning

5.	'457 Patent Claims 1, 5, 6, 10, 11, 14; '446 Patent Claims 1, 5, 6, 10	"primary circulation facility adapted to circulate"	[AGREED]	[AGREED]	Plain and Ordinary Meaning
6.	'457 Patent Claims 1, 5, 6, 10, 11, 14; '446 Patent Claims 1, 5, 6, 10	"substantially uniform recovery of the dielectric fluid"	[AGREED]	[AGREED]	Plain and Ordinary Meaning
7.	'457 Patent Claims 1, 5, 6, 10, 11, 14; '446 Patent Claims 1, 5, 6, 10	"primary fluid circulation facility"	[AGREED]	[AGREED]	Plain and Ordinary Meaning
8.	'457 Patent Claims 1, 5, 6, 10, 11, 14; '446 Patent Claims 1, 5, 6, 10	"plenum"	[AGREED]	[AGREED]	"a structure for dispensing liquid"
9.	'457 Patent Claims 1, 5, 6, 10, 11, 14; '446 Patent Claims 1, 5, 6, 10	"plenum, positioned adjacent the bottom of the tank"	[AGREED]	[AGREED]	Plain and Ordinary Meaning
10.	'457 Patent Claims 1, 5, 6, 10, 11, 14; '446 Patent Claims 1, 5, 6, 10	"a plenum . . . adapted to dispense"	[AGREED]	[AGREED]	Plain and Ordinary Meaning
11.	'457 Patent	"substantially uniformly upwardly"	[AGREED]	[AGREED]	Plain and Ordinary Meaning

	Claims 1, 5, 6, 10, 11, 14; '446 Patent Claims 1, 5, 6, 10				
12.	'457 Patent Claims 1, 5, 6, 10, 11, 14; '446 Patent Claims 1, 5, 6, 10	"a control facility"	[AGREED]	[AGREED]	Plain and Ordinary Meaning
13.	'457 Patent Claims 1, 5, 6, 10, 11, 14; '446 Patent Claims 1, 5, 6, 10	"as a function of the temperature"	[AGREED]	[AGREED]	Plain and Ordinary Meaning
14.	'457 Patent Claims 1, 5; '446 Patent Claim 1	"secondary fluid circulation facility"	[AGREED]	[AGREED]	Plain and Ordinary Meaning
15.	'457 Patent Claims 1, 5; '446 Patent Claim 1	"adapted to extract heat"	[AGREED]	[AGREED]	Plain and Ordinary Meaning
16.	'457 Patent Claims 1, 5; '446 Patent Claim 1	"dissipate to the environment the heat so extracted"	[AGREED]	[AGREED]	Plain and Ordinary Meaning
17.	'457 Patent Claims 5, 10, 14; '446 Patent Claims 5, 10	"communication facility adapted to facilitate monitoring and control"	[AGREED]	[AGREED]	Plain and Ordinary Meaning
18.	'457 Patent Claims 5, 10, 14; '446 Patent	"remote location"	[AGREED]	[AGREED]	Plain and Ordinary Meaning

	Claims 5, 10				
19.	'457 Patent Claims 1, 5, 6, 10	"over the weir"	[AGREED]	[AGREED]	Plain and Ordinary Meaning

II. Disputed Claim Terms.

The disputed claims, with the two (2) disputed claim terms bolded, are displayed below.

	Patent and Claim Number(s)	Claim Term	Plaintiff's Proposed Construction	Defendant's Proposed Construction	Judge's Construction
1.	'457 Patent Claim 1	"An appliance immersion cooling system comprising: a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising: **a weir,** integrated horizontally into the long wall of the tank adjacent all appliance slots, **having an overflow lip adapted to facilitate substantially uniform**	(i) Not indefinite; Plain and Ordinary Meaning (ii) Alternatively, "a weir … having an overflow edge or boundary capable of easing or helping substantially uniform recovery"	Immersion contends that this claim term is indefinite for failure to meet the requirements of 35 U.S.C. § 112(b) which renders the applicable claims invalid.	

		recovery of the dielectric fluid flowing through each appliance slot; and; a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir; a primary circulation facility adapted to circulate the dielectric fluid through the tank, comprising: a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot; a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the			

		environment the heat so extracted; and a control facility adapted to coordinate the operation of the primary and secondary fluid circulation facilities as a function of the temperature of the dielectric fluid in the tank."			
2.	'457 Patent Claim 6	"A tank module adapted for use in an appliance immersion cooling system, the tank module comprising: a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising: **a weir,** integrated horizontally into the long wall of the tank adjacent	(i) Not indefinite; Plain and Ordinary Meaning (ii) Alternatively, "a weir … having an overflow edge or boundary capable of easing or helping substantially uniform recovery"	Immersion contends that this claim term is indefinite for failure to meet the requirements of 35 U.S.C. § 112(b) which renders the applicable claims invalid.	

		all appliance slots, **having an overflow lip adapted to facilitate substantially uniform recovery** of the dielectric fluid flowing through each appliance slot; and; a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir; a primary circulation facility adapted to circulate the dielectric fluid through the tank, comprising: a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot; and a control facility adapted to control the operation of the primary fluid circulation facility as function of the temperature of the			

		dielectric fluid in the tank."			
3.	'457 Patent Claim 11	"A tank module (10) adapted for use in an appliance immersion cooling system, the tank module comprising: a tank (12) adapted to immerse in a dielectric fluid a plurality of electrical appliances (16), each in a respective appliance slot (18) distributed vertically along, and extending transverse to, a long wall of the tank (10), the tank (10) comprising: **a weir 22,** integrated horizontally into the long wall of the tank (10) adjacent all appliance slots (18), **adapted to facilitate substantially uniform recovery** of the dielectric fluid flowing through each appliance slot (18); a primary circulation facility (28) adapted to	(i) Not indefinite; Plain and Ordinary Meaning (ii) Alternatively, "a weir … capable of easing or helping substantially uniform recovery"	Immersion contends that this claim term is indefinite for failure to meet the requirements of 35 U.S.C. § 112(b) which renders the applicable claims invalid.	

		circulate the dielectric fluid through the tank (10), comprising: a plenum (36), positioned adjacent the bottom of the tank (10), adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot (18); and a control facility (58) adapted to control the operation of the primary fluid circulation facility (28) as a function of the temperature of the dielectric fluid in the tank (10)."			
4.	'446 Patent Claim 1	"An appliance immersion cooling system comprising: a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall	(i) Not indefinite; Plain and Ordinary Meaning (ii) Alternatively, "a weir … capable of easing or helping substantially uniform recovery"	Immersion contends that this claim term is indefinite for failure to meet the requirements of 35 U.S.C. § 112(b) which renders the applicable claims invalid.	

		of the tank, the tank comprising: **a weir,** integrated horizontally into the long wall of the tank adjacent all appliance slots, **adapted to facilitate substantially uniform recovery** of the dielectric fluid flowing through each appliance slot; a primary circulation facility adapted to circulate the dielectric fluid through the tank, comprising: a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot; a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the			

		environment the heat so extracted; and a control facility adapted to coordinate the operation of the primary and secondary fluid circulation facilities as a function of the temperature of the dielectric fluid in the tank."			
5.	'446 Patent Claim 6	"A tank module adapted for use in an appliance immersion cooling system, the tank module comprising: a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising: **a weir,** integrated horizontally into the long wall of the tank adjacent all appliance slots,	(i) Not indefinite; Plain and Ordinary Meaning (ii) Alternatively, "a weir … capable of easing or helping substantially uniform recovery"	Immersion contends that this claim term is indefinite for failure to meet the requirements of 35 U.S.C. § 112(b) which renders the applicable claims invalid.	

		adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot; a primary circulation facility adapted to circulate the dielectric fluid through the tank, comprising: a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot; and a control facility adapted to control the operation of the primary fluid circulation facility as a function of the temperature of the dielectric fluid in the tank."			

EXHIBIT F

UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF TEXAS
FORT WORTH DIVISION

MIDAS GREEN TECHNOLOGIES, LLC, **Plaintiff/Counter-Defendant,** **v.** **IMMERSION SYSTEMS, LLC,** **Defendant/Counter-Claimant.**	§ § § § § § § § § §	**Civil Action No. 4:20-cv-00555-O**

ORDER

Before the Court are Defendant Immersion Systems LLC's Opening Claim Construction Brief (ECF No. 74), filed September 24, 2021; Plaintiff Midas Green Technologies, LLC's Opening Claim Construction Brief (ECF No. 76), filed September 24; Immersion's Response (ECF No. 78), filed October 8; Midas's Response (ECF No. 80), filed October 8; and the Joint Claim Construction Chart (ECF No. 82), filed October 15.

Midas filed this lawsuit against Immersion, alleging infringement of two patents. Immersion denies that it has infringed any patents and argues that Midas's patents are invalid and unenforceable. Before reaching those issues, the parties ask the Court to resolve a dispute over the construction of two terms in the patent claims. The Court will also take this opportunity to adopt the agreed-upon constructions of the nineteen terms listed in the Joint Claim Construction Chart.

I. BACKGROUND

Midas is the assignee of two patents that concern the liquid cooling of electronic appliances. The first patent is registered as U.S. Patent No. 10,405,457 ("the '457 Patent"). Def.'s App. 6, ECF No. 75. The second patent is a continuation of the '457 Patent and is registered as U.S. Patent No. 10,820,446 ("the '446 Patent"). *Id.* at 22.

The patents describe a tank in which electronic appliances are immersed in a cooling fluid. *Id.* at 16, 32. A device on the bottom of the tank dispenses the fluid, which travels upward to the top of the tank. *Id.* When the fluid approaches the top, it reaches a horizontal slot called a "weir." *Id.* The fluid flows through the weir into a reservoir so that it can be repressurized, cooled, and recirculated through the system. *Id.* The technology has applications in data centers and cryptocurrency farming operations. *See* Pl.'s Br. 5, ECF No. 76.

On May 29, 2020, Midas sued Immersion for infringement of its patents. It asserts infringement of Claims 1, 6, and 11 of the '457 Patent, and Claims 1 and 6 of the '446 Patent. Compl. 7–8, ECF No. 1. Immersion responded by denying that it infringed any patents and asserting that the patents are invalid and unenforceable under 35 U.S.C. §§ 102, 103, and 112. Answer 11–13, ECF No. 17.

Following the Court's Scheduling Order, the parties submitted briefs regarding the construction of terms and phrases in both patents. They agree on the construction of nineteen terms and phrases. *See* Joint Claim Construction Chart 1–4, ECF No. 82-1. They dispute, however, the proper construction of two phrases:

1) "a weir . . . adapted to facilitate substantially uniform recovery,"[1] and
2) "a weir . . . having an overflow lip adapted to facilitate substantially uniform recovery."[2]

The parties agree that a "weir" is "an overflow structure or barrier that determines the level of liquid." *Id.* at 1. They also agree that "substantially uniform recovery" should be given its plain and ordinary meaning. *Id.*

[1] The first phrase appears in Claim 11 of the '457 Patent and Claims 1 and 6 of the '446 Patent. *See* Def.'s App. 15–16, 31, ECF No. 75.
[2] The second phrase appears in Claims 1 and 6 of the '457 Patent. *See id.* at 15.

The dispute comes down to the meaning of "an overflow lip." The '457 Patent describes "a weir . . . *having an overflow lip* adapted to facilitate substantially uniform recovery" of the fluid. Def.'s App. 19, ECF No. 75 (emphasis added). The '446 Patent, which followed the '457 Patent, omits the phrase "having an overflow lip," and instead describes "a weir . . . adapted to facilitate substantially uniform recovery" of the fluid. *Id.* at 35. The issue is whether there is a difference between a "weir" and a "weir having an overflow lip."

Immersion contends there must be a difference between the two phrases. It begins with the premise that different terms are presumed to have different meanings. *See* Def.'s Br. 15, ECF No. 74. So, Immersion argues, there must be a difference between the claims that include the phrase "having an overflow lip" and those that do not. And because the patents do not define what that difference is, Immersion argues the patents are indefinite under 35 U.S.C. § 112(b) and, thus, invalid.

Midas rejects Immersion's premise that the two phrases have different meanings. According to Midas, the inclusion of the phrase "having an overflow lip" is a redundancy; a "weir" and "a weir having an overflow lip" are the same thing. *See* Pl.'s Resp. Br. 7, ECF No. 80. Midas therefore argues that the two phrases need no construction because their meanings are plain. *See* Pl.'s Br. 1, ECF No. 76. In the alternative, Midas suggests that the meaning of the two phrases can be simplified by construing "adapted to facilitate" to mean "capable of easing or helping." *Id.*

II. LEGAL STANDARDS

In a patent infringement case, a court first determines the proper construction of the patent claims as a matter of law, establishing the scope of the patentee's rights. *Teva Pharms. USA, Inc. v. Sandoz, Inc.*, 574 U.S. 318, 321 (2015). The trier of fact may then be called upon to compare the properly construed claims to the allegedly infringing devices to determine whether there has been an infringement. *Id.*

Claim construction is the process of identifying the proper meaning of the claim language. "[T]he words of a claim 'are generally given their ordinary and customary meaning.'" *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312 (Fed. Cir. 2005) (en banc) (citation omitted). That is, a claim term is given "the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention." *Id.* at 1313. "There are only two exceptions to this general rule: 1) when a patentee sets out a definition and acts as his own lexicographer, or 2) when the patentee disavows the full scope of the claim term either in the specification or during prosecution." *Hill-Rom Servs., Inc. v. Stryker Corp.*, 755 F.3d 1367, 1371 (Fed. Cir. 2014) (internal quotation marks and citation omitted).

Courts begin the plain-meaning analysis by looking at the patent's intrinsic record, which consists of the claims, specification, and prosecution history. *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996). The words of the claims are generally given their ordinary meaning, but "it is always necessary to review the specification to determine whether the inventor has used any terms in a manner inconsistent with their ordinary meaning." *Id.* "[T]he specification is always highly relevant to the claim construction analysis. Usually, it is dispositive; it is the single best guide to the meaning of a disputed term." *Id.* A court may also consider the patent's prosecution history, if in evidence. *Id.*

Usually, the intrinsic evidence resolves any ambiguity in a term's meaning. When it does not, courts look to extrinsic evidence. *Vitronics*, 90 F.3d at 1583. Extrinsic evidence "consists of all evidence external to the patent and prosecution history, including expert and inventor testimony, dictionaries, and learned treatises." *Phillips*, 415 F.3d at 1317 (internal quotation marks and citation omitted). Though these sources may be useful, "a court should discount any expert

testimony 'that is clearly at odds with the claim construction mandated by the claims themselves, the written description, and the prosecution history.'" *Id.* at 1318 (citation omitted).

Sometimes, neither intrinsic nor extrinsic evidence can resolve a term's ambiguity. In those circumstances, the claim may be indefinite and thus invalid. *See* 35 U.S.C. § 112. "[A] patent is invalid for indefiniteness if its claims, read in light of the specification delineating the patent, and the prosecution history, fail to inform, with reasonable certainty, those skilled in the art about the scope of the invention." *Nautilus, Inc. v. Biosig Instruments, Inc.*, 572 U.S. 898, 901 (2014). Although the definiteness requirement mandates clarity, courts recognize that "absolute precision is unattainable." *Id.* at 910. The level of certainty regarding a patent's definiteness "is not greater than is reasonable," considering the patent's subject matter. *Id.* "[T]he party challenging the patent bears the burden of proving invalidity by clear and convincing evidence." *Takeda Pharm. Co. v. Zydus Pharms. USA, Inc.*, 743 F.3d 1359, 1366 (Fed. Cir. 2014) (citing *Microsoft Corp. v. i4i Ltd. P'ship*, 564 U.S. 91, 95 (2011)).

III. ANALYSIS

The lynchpin of Immersion's argument is the doctrine of claim differentiation. The doctrine holds that "different words or phrases used in separate claims are presumed to indicate that the claims have different meanings and scope." *Seachange Int'l, Inc. v. C-COR, Inc.*, 413 F.3d 1361, 1368 (Fed. Cir. 2005) (citation and internal quotation marks omitted). Claim differentiation, however, "is not a hard and fast rule of construction." *Id.* at 1369 (citation and internal quotation marks omitted). "The doctrine of claim differentiation can not broaden claims beyond their correct scope, determined in light of the specification and the prosecution history and any relevant extrinsic evidence. Claims that are written in different words may ultimately cover substantially the same subject matter." *Id.* (cleaned up).

The Court does not construe the claim language in isolation. "Claim language must always be read in view of the written description, and any presumption created by the doctrine of claim differentiation 'will be overcome by a contrary construction dictated by the written description or prosecution history.'" *Retractable Techs., Inc. v. Becton, Dickinson & Co.*, 653 F.3d 1296, 1305 (Fed. Cir. 2011) (citation omitted) (quoting *Seachange Int'l*, 413 F.3d at 1369). Finally, the presumption is "not as strong across related patents." *Clare v. Chrysler Grp. LLC*, 819 F.3d 1323, 1330 (Fed. Cir. 2016).

Immersion relies too heavily on the presumption of claim differentiation. The intrinsic evidence overcomes the presumption that a "weir" and a "a weir having an overflow lip" mean different things. Moreover, because the intrinsic evidence resolves the dispute over the meaning of the two phrases, the Court need not consult extrinsic evidence. *See Vitronics*, 90 F.3d at 1583. In sum, Immersion has not provided clear and convincing evidence that the patents fail to inform "those skilled in the art about the scope of the invention." *Nautilus*, 572 U.S. at 901; *see also Takeda Pharm.*, 743 F.3d at 1366.

A. The Claims

The parties' stipulated claim terms resolve any ambiguity in the disputed terms. As already noted, the parties agree that a "weir" is "an overflow structure or barrier that determines the level of liquid." Joint Claim Construction Chart 1, ECF No. 82-1. They also agree that "substantially uniform recovery" should be afforded its plain and ordinary meaning. *Id.* A person of ordinary skill in the art would understand that a weir, as "an overflow structure or barrier," determines the level of a liquid by having an edge over which the liquid flows. The parties' agreements therefore provide reasonable certainty as to the scope of the claim. *See Phillips*, 415 F.3d at 1312.

The question is whether adding the phrase "having an overflow lip" injects ambiguity into the claims. It does not. As Midas points out, the overflow lip is simply the bottom edge of the weir.

See Pl.'s Resp. Br. 8–9, ECF No. 80. The Court agrees that specifying that a weir has an overflow lip is redundant. And redundancies do not necessarily render a claim indefinite. For example, one court rejected an argument that the phrase "inner shell" used in one patent and the phrase "inner shell that is a rigid shell" used in a related patent must have different meanings. *Kranos IP Corp. v. Riddell, Inc.*, No. 17-C-6802, 2019 WL 1915366, at *2 (N.D. Ill. Apr. 24, 2019) (cleaned up). The Court reasoned that "the fact that a related patent contained different claim language has little probative value in light of the clear indications in the [other] patent that the inner shell must be rigid or hard." *Id.* Likewise, that the later '446 Patent omitted the phrase "having an overflow lip" is simply confirmation that the applicants recognized the redundancy. *See Shire LLC v. Abhai, LLC*, 219 F. Supp. 3d 241, 245 (D. Mass. 2016) ("Differently worded but similar claims in related patents, however, may still be construed identically where those patents share a specification and other technical details.").

B. The Specification

The specification reinforces the plain meaning of the disputed terms. The '457 Patent describes how the fluid flows into the reservoir: "One further shared component is the dielectric fluid recovery facility comprising a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted smoothly to receive the dielectric fluid as it flows over the weir." Def.'s App. 16, ECF No. 75 (references omitted). Figures 1, 5, and 6 show that the overflow lip is simply the bottom edge of the weir. *Id.* at 8, 10. The specification reinforces the conclusion that a "weir" and a "weir having an overflow lip" are precisely the same thing.

Immersion's argument to the contrary misses the point. Immersion argues that "[n]owhere in the specification or claims is there any suggestion as to how the terms differ." Def.'s Br. 17, ECF No. 74. But Midas's position—and the plain language of the claims—is that the terms do *not* differ. Again, Immersion relies too heavily on claim differentiation in assuming that "weir" and

"weir having an overflow lip" must mean different things. The claims and specification demonstrate that the most reasonable interpretation is that "weir" and "weir having an overflow lip" are identical in meaning. *See Retractable Techs., Inc.*, 653 F.3d at 1305. Immersion does not rebut that reasonable interpretation.

C. The Prosecution History

The prosecution history resolves any remaining uncertainty about the meaning of the disputed terms. An examiner rejected the initial application for the '457 Patent because it was too similar to an already-patented air cooling system. *See* Def.'s App. 39–42, ECF No. 75. The applicants then added the phrase "having an overflow lip" to Claims 1 and 6 to clarify that the '457 Patent concerned liquid cooling, not air cooling. *Id.* at 45–48. The examiner again rejected the application, observing that "the 'weir' structure . . . merely amounts to an opening in a wall and its 'lip' is never defined as more than the bottom surface of that opening." *Id.* at 88. So the applicants submitted another revised application, explaining in detail the difference between gas and liquid fluid dynamics. *Id.* at 100–01. After that final explanation, the examiner dropped the air cooling system as a prior-art reference and approved the '457 Patent. *See* Pl.'s Supp. App. 348–50, ECF No. 81.

The prosecution history confirms several points. First, stating that a weir has an overflow lip is redundant. As the examiner observed, the lip is merely "the bottom surface of [the weir's] opening." Def.'s App. 88, ECF No. 75. Or, as Midas says, "All weirs have overflow lips." Pl.'s Resp. Br. 8, ECF No. 80. Second, the '457 Patent applicants added the phrase "having an overflow lip" to underscore that the patent concerned a liquid cooling system rather than an air cooling system. As it turned out, adding the phrase did not help—the examiner required more explanation to distinguish the liquid and air cooling systems. Once the applicants provided that explanation, the patent was approved. Third, the omission of the phrase "having an overflow lip" from the

subsequent '446 Patent did not change the claims' meaning. The applicants for the '446 Patent simply acknowledged the examiner's conclusion that the phrase was redundant. They omitted the phrase because it added nothing to the description of a weir. The prosecution's history confirms that a personal of ordinary skill in the art would understand the scope of the disputed phrases according to their plain meaning.

IV. CONCLUSION

The intrinsic evidence demonstrates that the disputed terms should be afforded their plain and ordinary meanings. The Court therefore need not consult any extrinsic evidence. *See Vitronics*, 90 F.3d at 1583. The Court also **DENIES** Immersion's invalidity claim because Immersion has not shown by clear and convincing evidence that the patents are indefinite. Accordingly, the Court **ORDERS** the following:

1) The Court construes the nineteen agreed-upon terms and phrases in the Joint Claim Construction Chart (ECF No. 82-1) in accordance with the parties' agreed constructions.

2) The Court construes the two disputed phrases (a) as not indefinite and (b) in accordance with their plain and ordinary meaning.

3) The Court refers the parties to the Amended Scheduling Order (ECF No. 64) regarding future litigation deadlines.

SO ORDERED this **22nd day** of **November 2021**.

Reed O'Connor
UNITED STATES DISTRICT JUDGE